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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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Why Street Cleaning Departments Should Be Headed by Engineers

A study made by the Rockefeller Foundation shows that only one in nine of the "responsible heads of health departments in 72 municipalities and 48 states" has had any special training for his work. Imagine the public consternation if it were a fact that only 11 per cent of all bridge designers had had a course in structural engineering, yet an almost exact parallel to such an hypothetical condition exists in our public health departments; for while 91 per cent of the heads of public health departments are physicians, not one in ten of them has qualified himself to fill such a position by the special training essential to the highest degree of efficiency.

Probably this deplorable condition exists because to the public a professional degree is erroneously supposed to indicate that its possessor is sufficiently educated to practice successfully in any branch of the profession. But, after all, is the public to blame? In this particular case are not the physicians to blame? Does the duty not rest with them to tell the public that merely because a man holds an M. D. diploma does not qualify him to be the responsible head of a city health department?

Similarly it is well known to civil engineers that many incompetent men hold responsible public positions of an engineering nature. Is it not the duty of professional engineering societies to guide the public in the selection of the heads of engineering departments of cities, counties and states? Silence in such matters must be construed by the public as meaning assent.

Then, too, there are many public departments that should be headed by engineers, even though the word engineering does not appear in the title of the department. For example, the street cleaning department of a city should be in charge of a municipal engineer experienced in street sanitation. If this were universally the case, there is little doubt in our minds that respiratory disease cases would soon be greatly reduced in number. Sanitary engineers have almost eliminated typhoid fever by filtration and chlorination. We believe that thorough and frequent flushing of streets with chemicalized water would destroy or remove most of the germs that cause tuberculosis, grippe and pneumonia.

Politicians at the head of street cleaning departments may be well meaning enough, but usually their ignorance of sanitation prevents their showing much inclination to clean the streets in such a thorough manner that microbe laden dust will cease to exist.

Is "State Aid" an "Expensive Phrase?"

In addressing a commencement audience in Colorado, ex-Governor Lowden of Illinois said: "No more expensive phrases have been invented in recent years than 'state aid' and 'federal aid.'" He spoke with special reference to state and federal aid laws that provide money for road construction.

Ex-Governor Lowden is a business man who was an excellent governor, but this utterance illustrates again the sort of error that any man is apt to make when he talks about matters that he has studied only cursorily, if at all. Had he taken the pains to look up road building history in America, he would have learned that it was not till 30 years ago that this country made a real start in pulling itself out of the mud. New Jersey passed a state-aid law in 1891, and set the example that other states began slowly to follow. Prior to that time the farmers of America had resolutely opposed any adequate program of road improvement, because they refused to bear the full burden of taxation for a thing that benefited the rest of the public quite as much as it benefited them. But when state aid lifted half the tax burden off the farmers' backs, then, little by little, they began to favor adequate road improvement. Even so, the progress toward better roads was painfully slow until Uncle Sam "came across" with a few million dollars ($5,000,000) of federal aid money for roads. That was in 1916, and now every state in the union has a state highway department and is in a fair way to have a reasonable mileage of good roads within the next 10 or 15 years.

Ex-Governor Lowden's own state, Illinois, is one of the richest and yet almost the worst paved in America, because it waited 25 years after New Jersey showed it the way before it, too, adopted a state aid road program.

If the "state aid" and "federal aid" programs are leading to extravagance in road construction, ex-Governor Lowden might have a sound argument against what he calls those "expensive phrases", but he fails to show that this is the case. The fact is that he can not show it to be so, and he talks qualitatively when he should talk quantitatively. He tells an audience that state and federal aid are "expensive." So they are. So is buying food and clothing. But he fails to tell them how expensive, and, what is worse, he fails to tell them how profitable such expenditures are. Any economic program could be wrecked by looking only at the debit side of the ledger. How about the credit side?

The federal government budget for the year 1922 provides for $3,800,000,000, of which $165,000,000 was allowed for roads; but congress has decided to cut the road appropriation for 1923 to $50,000,000, or a trifle more than 1 per cent of the total budget. Not much extravagance in this sort of "federal aid" in road building.

It is estimated that taxes in America total about seven billion dollars a year, or 12 per cent of the total income. Road construction is annually costing about $750,000,000, or one-tenth of total taxes, or one and a quarter per cent of the total income, or $7 per capita. Ford alone is producing one and a quarter million cars a year, with a market value of $400,000,000, or more than half the total expenditure for roads. Three times as much is being spent annually for new motor cars and trucks as for road and street improvement. Does this look like extravagance in highway construction? The fact is that if motor vehicles are needed in any such numbers as sales indicate, road and street construction is lagging far behind the economic requirements.

Shortages in Railway and Highway Construction

The following weekly summary was written by the editor of Engineering & Contracting for the Chicago Journal of Commerce:

Civil engineering is divisible into four major fields: (1) Highways (roads and streets), (2) hydraulics (waterworks, irrigation, canals and sewers), (3) railways (steam and electric), and (4) structures (bridges, industrial and business buildings, etc.).

Of these four fields, the first and fourth far exceed the second and third in present annual expenditures for construction. During 1921 the following were approximate expenditures for new construction by contract:

Highways	$500,000,000
Waterworks	60,000,000
Sewers	60,000,000
Business and industrial buildings	750,000,000

Data are not yet available for estimating steam and electric railway construction in 1921, but construction in that field was at a very low ebb, due to inadequate net earnings on railway investments. For ten years prior to the war steam railway construction averaged about $500,000,000 annually, and electric railway construction probably averaged $150,000,000 annually. But during the six years of 1914 to 1918, inclusive, less than $100,000,000 a year was spent by the steam railways for construction and rolling stock combined, and probably one-third of this was for rolling stock. The last three years have been no better, so that railway construction has sunk to a sadly low level.

Construction contracts for roads and streets during the first five months of 1920 exceeded the corresponding period of 1921 by 20 per cent in money, and by 50 per cent in quantity of material and days of labor. Hence, we may look for fully $600,000,000 worth of road and street contracts in 1922. In addition to this there is a large but less accurately known amount of highway work done by day labor under engineers employed by cities, counties and states. Probably this day labor work totals $150,000,000. But certainly the common talk of a billion dollars a year spent for road improvement is a greatly exaggerated estimate. Estimators have apparently erred by assuming that an appropriation for road work is equivalent to an expenditure of the full amount of the appropriation within the year. Usually road appropriations extend over two or more years.

During 1914-1921 the number of motor vehicles increased 700 per cent, but expenditures for roads increased only 260 per cent. In other words, highway improvement has by no means kept pace with the requirements.

$190,000,000 Authorized for Continuing Federal Aid Road Construction

Federal aid for road construction will be continued as a result of the authorization of additional appropriations for this work amounting to $190,000,000 carried by the postoffice appropriation bill signed by the President June 19. Fifty million dollars is authorized for the fiscal year beginning July 1, this year, and $65,000,000 and $75,000,000, respectively, are authorized for each of the two succeeding fiscal years. In addition, $6,500,000 is authorized for forest roads for each of the two fiscal years beginning July 1, 1923, and July 1, 1924. The funds will be administered by the Secretary of Agriculture through the Bureau of Public Roads.

Allotment to the States.—The apportionment to be made to the various states is approximately as follows:

	Fiscal year ending 1923.		Fiscal year ending 1923.
Alabama	$1,035,614	Nevada	635,624
Arizona	702,188	New Hampshire	243,750
Arkansas	836,095	New Jersey	628,581
California	1,641,399	New Mexico	793,216
Colorado	894,117	New York	2,464,200
Connecticut	320,599	North Carolina	1,139,556
Delaware	243,750	North Dakota	776,476
Florida	591,217	Ohio	1,882,003
Georgia	1,331,972	Oklahoma	1,168,226
Idaho	625,691	Oregon	788,443
Illinois	2,164,187	Pennsylvania	2,265,969
Indiana	1,305,904	Rhode Island	243,750
Iowa	1,401,915	South Carolina	707,492
Kansas	1,401,521	South Dakota	802,707
Kentucky	944,786	Tennessee	1,098,461
Louisiana	664,660	Texas	2,950,115
Maine	463,440	Utah	566,278
Maryland	427,086	Vermont	243,750
Massachusetts	730,784	Virginia	971,219
Michigan	1,499,688	Washington	735,806
Minnesota	1,415,731	West Virginia	534,906
Mississippi	863,271	Wisconsin	1,263,211
Missouri	1,632,086	Wyoming	623,078
Montana	1,031,257		
Nebraska	1,054,126	Total	$48,750,000

These funds must be matched by the states and will be administered subject to the general provisions already in force.

The new legislation reduces the maximum participation on the part of the Government from $20,000 to $16,250 per mile for roads constructed with the appropriation for the next fiscal year and $15,000 per mile thereafter. Bridges over 20 ft. in span may be considered as separate projects to which this limitation does not apply. In states where more than 5 per cent of the area is unappropriated public land provision is made for an increase in the amount per mile. The act also provides for the extension of federal aid to the construction of structures required for the elimination of railroad grade crossings.

Plans Received from All but Eight States.—Plans for the proposed system have been received by the Bureau of Public Roads from all but 8 states, and the state systems are being co-ordinated so that when joined together they will serve the best interests of the whole country. In the meantime only projects certain to be on the proposed system are being approved.

The new appropriation comes at a time when several states are nearing the limit of funds available. The authorization of funds for three years in advance will be of great benefit to all states in that it will permit them to lay their plans for some time ahead. Uncertainty as to future federal aid is removed and provision can be made at once for raising state funds to match it.

What the new funds will mean to the country can be judged by the use that has been made of the $350,000,000 previously appropriated. On May 31, 17,000 miles of road had been completed, and, in addition nearly 14,500 miles were under construction. Federal-aid roads in all stages total nearly 38,700 miles, involving over $287,500,000 of federal aid. To match this fund, the states have appropriated $380,000,000, making a total of $667,500,000.

It is estimated that the $190,000,000 lately authorized will result in the construction of more than 25,000 miles, which, added to the 46,000 miles that is expected to result from previous appropriations makes a total of 71,000 miles.

"H. G. Wells Picks Out the Six Greatest Men in History"

By HALBERT P. GILLETTE, Editor.

Maybe he does, but probably he doesn't. At any rate he does not balk at the task set for him by The American Magazine, for he selects Jesus, Buddha, Asoka, Lincoln, Aristotle and Roger Bacon. It will be seen that ethics and religion claim two; statesmanship, two; science, two; esthetics and art, none.

Wells dimly recognized that when relative degrees of magnitude are to be measured some common unit must be used; but how dim was his perception of this important logical principle will be apparent not only from his statement of his standard of "greatness" but from his application of it to different men.

As to his standard of greatness Wells says:

> For the historian's test of greatness is not, "What did he accumulate for himself?" or, "What did he build up, to tumble down at his death?" Not that at all, but this: "Was the world different because he lived? Did he start men to thinking along fresh lines with a vigor and vitality that persisted after him?" By this test Jesus stands first; and if you ask for another name to write under his, there is Buddha.

Note the vagueness of this standard of greatness. Presumably he had in mind the number of men whose thinking and acting has been influenced by the great man, but he does not say a word about numbers. Without measurement or enumeration of some sort, how is relative greatness to be determined?

Presumably Wells had it in mind roughly to estimate the number of men whose happiness has been enhanced by the great man, but he does not say so in stating his standard of greatness. In short he starts to measure human greatness without stating precisely what unit he purposes using and how he purposes estimating the number of units to be credited to each candidate for greatest greatness. He is, therefore, unscientific and his statements and inferences carry no more weight than bare naming of the six greatest men would carry.

Suppose we assume that a complete statement of his standard of greatness were: The greatness of a man is measured by the number of men whose lives have been influenced by him for good.

A definite statement such as this immediately begets trouble for the analysist. Question arises as to how the number of men "influenced for good" is to be ascertained; and what is "good"? Then, too, the earlier a great man comes in history, the more men has he had a chance to influence, so how is the more modern great man to be "equated" for this difference in opportunity to influence many men?

It needs but a little scientific study of this problem to disclose the complete lack of such study on the part of H. G. Wells. Although his early education was scientific, he has been so long divorced from scientific practice that he has lost nearly all the benefits derivable from science save his admiration for science. Possibly he might reply that he is speaking as a historian and not as a scientist when he essays to estimate human greatness. Granted, but even a historian can not escape the use of at least one science, namely the science of arithmetic. And it is a principle of arithmetic that only like units can be added to, subtracted from, multiplied or divided by one another. This principle Wells violates when he undertakes to measure mental magnitudes without defining his unit and adhering to that same unit in measuring all mental greatness.

If an attempt is seriously made to do this, it is quickly seen that no two men who have been great in entirely different fields can be compared as to relative greatness. Gotch was the greatest of wrestlers at one time. Jefferies the greatest of pugilists, and Kelly the greatest of sprint racers. Who can tell us which of these three was the greatest athlete? No one can tell, for there is no common unit by which wrestling, fighting and running prowess can be measured. Similarly, as to mental activities. Who was the greatest, Newton, Shakespeare or Michael Angelo? The absurdity of the query is written on its face.

In his selection of Aristotle and Roger Bacon in the field of science. Wells shows an amazing ignorance of scientific history. Aristotle is almost universally regarded by scientific historians as having done more to retard science than to advance it. It was the deadening influence of Aristotle's methods of investigation that Francis Bacon inveighed against and that Descartes scouted. In his History of the Inductive Sciences, Whewell says of Aristotle's treatises on the natural sciences that they "contain an extraordinary accumulation of facts and manifest a wonderful power of systematizing; but are not works which expound principles, and, therefore, do not require to be here considered"; and he adds, "In the existing body of science there are no doctrines for which we are indebted to the Aristotlean school." Whewell sums up Aristotle's claim to greatness in physical science thus: "The Aristotolean physics can not be considered as other than a complete failure. It collected no general laws from facts; and consequently, when it tried to explain facts, it had no principles which were of any avail."

So, although Whewell acknowledges Aristotle's ability as a gatherer and classifier or catologer of facts, he concludes that Aristotle was unable either to use them effectively or to teach others how to use them.

Bearing in mind that Whewell spent a large part of his life studying and writing his monumental histories of science, and that he was a very capable man, Wells would have to produce very strong evidence to controvert successfully Whewell's conclusions about Aristotle's place in science.

With scarcely less astonishment we see the name of Roger Bacon as one of the two greatest scientists. Roger Bacon has been called the literary godfather of Francis Bacon, who wrote 400 years later. In his "Philosophy of Discovery," Whewell says: "We know but little of the biography of Roger Bacon, but we have every reason to believe that his influence upon his age was not great." If so, Wells' criterion of greatness seems not to have been applied to Roger Bacon. Although Roger Bacon wrote earnestly and well, advocating experimentation and himself conducting experiments, so little did he change the current trend of thought that science did not begin to make real progress until more than three centuries after his death.

Leonardo da Vinci (engineer and architect), Copernicus, Galileo, Kepler typify the men who gave to science its great modern impulse, 1,800 years after Archimedes had shown the value of quantitative observation and experimentation. Then came Francis Bacon who preached their methods, but without giving credit to the scources of his inspiration.

So far as science is concerned, I regard it as impossible to prove who have been its two greatest, or its n greatest exponents have been. Equally impossible is it to select a number of men from all walks of life and prove that they are the six or the n greatest in history.

The editor of The American Magazine asked a question, Who are the six greatest men in history? Wells showed the scantness of his logical equipment by attempting to answer the question.

Mixing Cement with Soil in Road Building

Mixing cement with certain types of soil to alter the characteristics of the soils and make them more suitable for road surfacing and subgrades is an experiment recently conducted by the U. S. Bureau of Public Roads, which is now proving its value in actual use. The treatment was first suggested and tried out at the Arlington Experimental Station of the bureau. Results warranted a field test, and it was arranged with the California State Highway Department to try it on the adobe soil there.

A part of a federal-aid project in Solano county was selected for the test. The dry soil was well broken up and harrowed to a depth varying from 6 to 12 in. and mixed with cement in the proportions of 1 part cement to 10 parts soil and 1 part cement to 20 parts soil. It was intended to water and roll the surface, but rain prevented. One section was allowed to remain untreated for purposes of comparison.

A recent inspection showed that the untreated section was badly broken up, due to the usual shrinkage cracks characteristic of adobe soils. The treated sections were in good condition and showed no shrinkage cracks. The treatment is not intended to make a hard surface like concrete, but to alter the properties of the soil so that it will be stable and lessen the effects of moisture.

California plans to conduct additional experiments, which will be observed in detail by the bureau and cost data obtained.

Highway Curves and Recommended Practice to Increase Safety of Traffic

A Committee Report Presented May 12, by H. Eltinge Breed, Chairman, at the Annual Meeting of the National Highway Traffic Association

Your Committee on Status of the Construction of Highway Curves and Recommended Practice to Increase Safety of Traffic made last year a progress report. This year it can offer definite recommendations for your decision, suggestions for your discussion, and projects for your consideration.

The importance of safety on the highway, experienced more or less vaguely by all those interested in highway traffic, becomes tangible through definite figures. There are now registered in the United States 10,500,000 motor vehicles. This year's increase to that number is estimated by manufacturers at 1,800,000. The risk to safety lies in the congestion of 90 per cent of these vehicles upon 10 per cent of our roads. This risk we must minimize. That it is at present fraught with appalling loss of human life is evidenced by the casualties from automotive vehicle accidents—a loss yearly greater than is incurred by all other means of transportation combined.

Five Conditions Under Which Accidents Occur.—The majority of these accidents of congestion occur under five conditions, all of which road builders may help to eliminate:

1. Sight distance on curves, both horizontal and vertical, which is insufficient to permit precaution against the other man's reckless driving. Lack of sight distance also increases the accidents at intersecting roads and at railroad crossings.

2. Insufficient width of pavement, especially in congested districts, which increases the number of cars that turn turtle on soft shoulders and hurtle down unprotected slopes.

3. The inadequate, irregular and improper spacing of danger signs which encourages a general carelessness of their import. Judged by the number of accidents in their vicinity, they are a spur to the recklessness of the joy rider and a consequent risk to his sober brethren.

4. The tendency of detours under traffic to become almost impassable. On heavy-traveled routes traffic going in different directions should be routed over different detours; or if detours are inadvisable on account of dangerous or impassable conditions, the road should be built horizontally a half at a time.

5. Railroad grade crossings. To help prevent accidents to which these and other highway conditions are conducive, we may proceed at four points: first, to secure good design for new roads; second, to promote adequate improvement of old roads; third, to insist upon reconstruction of existing roads at places that have proven especially dangerous, such as grade crossings; fourth, to improve the location of the center line on dangerous curves and elevations. Under these headings the following recommendations are made. They aim to promote the safety of the traveling public as far as impersonal factors can do it, and they aim to diminish as far as possible the personal menace projected by the reckless driver. Safety for the careful with protection from the careless.

Necessity for Standard Practice Throughout Country.—First of all, under the consideration of general safety for traffic, comes the necessity of standard practice throughout the country in respect to placement of danger signals, elevation and banking of curves, widening and regulation of traffic on curves. Standardization in these matters is imperative because with the completion of transcontinental routes there is increasing interstate traffic. Drivers traveling to remote sections cannot be expected to apprehend distinctions in practice now existing between different highway departments, yet departure in our state from what they have become accustomed to expect in others, is a frequent cause of disaster. There is no real obstacle in the way of this standardization; it is merely a matter of agreement among state highway officials and motor organizations.

Therefore your committee proposes that you discuss, alter and finally recommend for standard practice the following resolutions in respect to general safety of highway traffic and to special precautions on curves:

Recommendations Regarding Curves.—First, that on all curves of more than three degrees the pavement and inner half of the earth shoulder be banked. This super-elevation should vary from 0 for a 3-degree curve, to 1 in. per foot of width for curves of 20 degrees or sharper.

Second, that on all curves of more than 4 degrees the pavement be widened on the inside $\frac{1}{2}$ foot for each 1 degree increase in curvature.

The widening and banking on a 4-degree curve should start at a minimum of 50 ft. before reaching the P. C. (beginning of curve) and come to the fully widened and banked section at or very soon after reaching the P. C. . Inversely the regular section should be reached at a minimum of 50 ft. beyond the P. T. (end of curve); for a 20-degree curve, this varying or transitional width should be about 150 ft. long, with proportional lengths for intermediate curvatures.

Third, that a line about 4 in. in width of appropriate color be painted on the center line of pavement on all curves, both vertical and horizontal, this painted line to be renewed as necessary in order to keep it conspicuous and that it may indicate to traffic in each direction the limit of its half width of pavement.

Fourth, that all sharp or dangerous curves, either simple or reverse, horizontal or vertical, should be posted about 500 ft. from each end with a sign indicating that danger exists and the direction of curvature. Railroad crossings at grade should be posted in a similar manner.

Fifth, that the National Highway Traffic Association recommend to all legislative committees preparing motor traffic laws that the attempt to pass a motor vehicle while going in the same direction on a curve either horizontal or vertical where the unobstructed line of vision is less than 500 ft. be made a misdemeanor; and that all damages resulting from an accident under these circumstances be placed upon the passer.

Sixth, that the minimum radius of curves be 300 ft. unless prevented by an approach to a bridge not practicable to change or the improvement being on a village or city street; even to the end that new "right of way" should be procured in order to increase the radius, bearing in mind that the improvement is being made for a long time, and that land values may increase to an extent prohibitive to procuring more right of way.

Seventh, that providing there is sufficient space within the "right of way" earth slopes be carried out with a 4 on 1 slope. If this is not possible, guide rail should be placed on the inner edge of all curves of more than 8 degrees. This rail should be kept painted white and be about 4 ft. in height.

Eighth, that in order to prevent the shoulders adjacent to hard surfaced pavements from being gouged out, gravel or crushed stone, of suitable sizes to insure stability, should be placed 2 ft. in width and 4 in. in depth, on each side of the pavement, and maintained at the level of the pavement. An application of hot tar or asphalt cement on the gravel or stone will be found beneficial.

Ninth, that, in the interests of public safety, all advertising signs and obstructions along highway routes be eliminated, except those erected for public benefit by the direction or permission of officials having jurisdiction over the highways.

Tenth, that a definite sum be set aside annually by each highway department, and a comprehensive plan devised on which annual progress may be made, for the elimination of the most dangerous grade crossings.

Suggestions for Future Projects.—There are also suggestions and projects for the future that your committee would like to offer as a sort of progress report for your comment and opinion. They are debatable—are they sufficiently valuable to be accepted as working hypothesis to be proven by experimentation?

We believe that to minimize danger the proper highway officials in each community should make a survey of the bridges in that community and determine to what extent, if any, they had to be strengthened in order to assure adequate support to increasing traffic. At present, some of us are in daily fear of disaster to heavy motor buses laden with humanity.

We believe that many congested routes should be widened as an economic and satisfactory method to safeguard traffic.

We question whether the increased security to the public and saving of time would not justify the cost of grade separations for traffic at intersecting crossings on heavily congested routes approaching large cities.

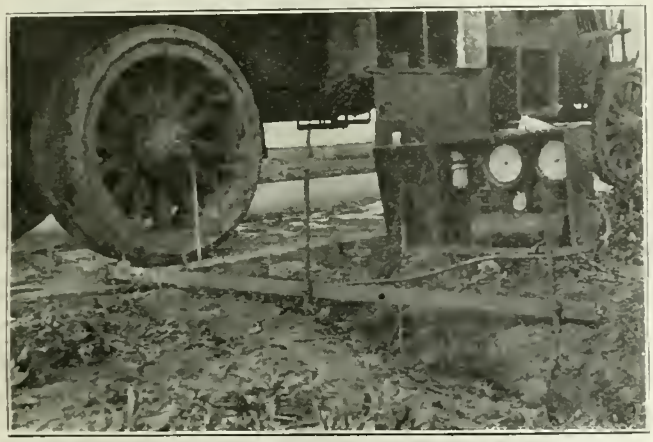
Distribution of Wheel Load on Pavement Sections

A Report of One of the Highway Research Investigations Carried on by the Illinois Division of Highways, the U. S. Bureau of Public Roads Cooperating

By H. F. CLEMMER and C. A. HOGENTOGLER,

Engineer of Tests, Illinois Division of Highways, and Highway Engineer, U. S. Bureau of Public Roads.

Part of the investigational work carried on at the Bates Experimental Road, under the direction of Clifford Older, Chief Engineer of the Illinois Division of Highways, consisted of observations for determining the deflections of the various surfaces, and corresponding pressures delivered to the subgrade during the passage of heavy motor truck wheels. The behavior of corners adjacent to joints, as well as other parts of the sections, were observed. Ames dials, supported independently of the pavement, were used for measuring deflections, while subgrade pressures were obtained by means of pressure cells which were supplied by the U. S. Bureau of Public Roads. During construction 25 cells were placed in the road, 12 being in corners 18 in. from each the joint and side edge, and 13 in other parts of the sections. The procedure in pressure cell installation and manipulation was similar to that used on the Camp Humphrey road test.* Types of pavements observed were monolithic and semi-monolithic, brick, concrete and bituminous filled brick on macadam base.



Pressure Cell Apparatus, Ames Dials and Truck Wheel During Test.

How the Observations Were Made.—For obtaining information at the corners, pressures and readings on two Ames dials, one each side of the joint 1 in. from the side edge of the pavement, were taken when the rear wheel of a motor truck moving across the joint, was placed at intervals of 1 ft. for a distance of 4 ft. each side of the joint and at intervals of 2 ft., through a distance of from 4 to 18 ft. each side of the joint. Observations at points other than corners were made in a manner similar to that described above, excepting that but one Ames dial was used instead of two. This dial was supported on a ¾-in. iron rod driven 4 ft. into the subgrade through the surface at a point from which a test core was taken. A record also was made of pressures, deflections and air temperatures both before and after each set of observations. Moisture content of subgrades was determined at each point observed. The motor truck used has front and rear wheel weights of 3,340 and 7,150 lbs. respectively.

In all, six sets of observations were made, one about noon and one about midnight on both Aug. 8 and Oct. 25, 1921, as well as day runs on March 6 and April 17, 1922. From noon and midnight sets it was hoped to learn more about the effects of slab warping, a discussion of which has been given in a previous paper,† while those taken at several different times of the year were expected to show effects of season changes.

What the Influence Curves Show.—This work requires taking about 2,000 pressure cell and 6,000 dial readings, from which were secured about 150 influence curves. These influence curves show (1) the distances from points observed at which the influence of the wheel load was felt, and (2) the pressures exerted on the subgrade by such deformations as were caused by surface deflections. In addition to the above, the curves secured from corner loadings disclose the ability of joints to transfer loads on one section, to the adjacent section, and also the vertical movement of the two sections due to the fact that perfect contact between the two did not exist.

A study of the corner curves failed to show any definite relation between the deflection and load or deflection and thickness of surface. Without exception, however, the deflections at night were greater than those which occurred in daytime, showing clearly that during the cooler part of the day, due to warping, the edges of rigid road slabs are curled upward, while in the warmer part, they are curled downward. In addition to this curling, and due to the same cause, temperature change, there was noted also longitudinal contraction and expansion of the sections, allowing better distribution of the load across joints during the day than at night.

Some Typical Influence Curves and What They Indicate.—Typical corner influence curves are shown in Fig. 1. The curves for Section No. 37 indicate that at the joint between the monolithic sections Nos. 37 (3-in. brick and 3-in. base) and 38 (4-in. brick and 3-in. base) perfect contact existed both day and night. The curves for Section No. 40 indicate that at the joint between these two 9-in. concrete slabs very little connection existed either night or day. This condition was due to the fact that original joint was chiseled out to a width of 1 in. and later filled with Portland cement grout.

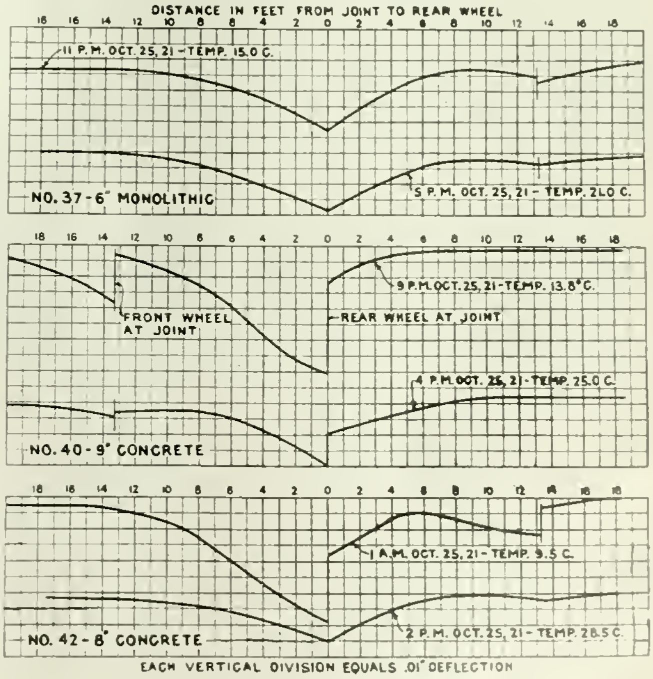


Fig. 1—Typical Corner Influence Curves.

The curves for Section No. 42 indicate that at the joint between the 8 and 7-in. concrete slabs excellent contact existed during the day and but very little at night, thus showing the effect of longitudinal contraction and expansion due to temperature changes. A scrutiny of these curves shows that the greater deflections occur at night. In Section No. 37 where perfect contact existed the difference between day and night deflections was but .008 in.; in Section No. 42 where perfect contact existed only during the day, the difference was .048 in., and in Section No. 40, where perfect contact existed neither time, the difference in deflections was .041 in., thus indicating that the warping was considerably less when perfect contact between sections existed. This set of curves shows the deflections of a corner caused when the rear truck wheel is placed at different distances from it.

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*Thickness of Concrete Slabs, by A. T. Goldbeck, Public Roads, April, 1919.

†Bates Experimental Road, by Clifford Older, read at meeting of American Association of State Highway Officials, Omaha, Nebr., Dec. 8, 1921.

The curves in Fig. 2 arranged differently, show the behavior of corners on opposite sides of the joint when a truck wheel passes from one side to the other. When contact between sections is not perfect a movement occurs which causes the ends of the slabs, if they are close enough together to rub against each other, which action can cause shattering or feathering of the joints. Between Sections Nos. 44 and 45, where no contact exists, the movement or distance of rubbing was .187 in. In Sections Nos. 51 and 52, where partial contact was indicated, this rubbing distance was slightly more than .1 in., notwithstanding the fact that the total deflections are about the same as those of 44 and 45. Between Sections Nos. 40 and 39, where perfect connection existed, the rubbing movement was completely eliminated.

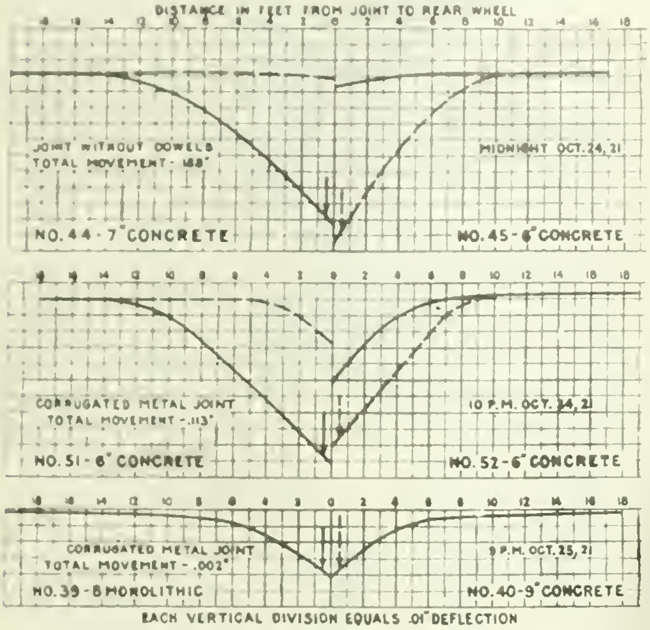


Fig. 2—Curves Showing Behavior of Corners When Truck Wheel Passes Over Joint.

Deflections of Slab Corners Adjacent to Joints.—Since the observed deflections because of different conditions of contact between sections were caused by varying loads, it was necessary before comparisons were made to know the deflections which would have occurred had the same conditions of contact existed at the joints. By assuming perfect contact, values were obtained from the formulae shown in Fig. 3, and furnished a basis of comparison. These values are but approximate since the assumption made in their derivation was that the deflection of the corner varied directly as the load. These computed values, together with the observed deflections and the total movements or "distances of rubbing" for the day and night readings on Oct. 25, 1921, are given in Table 1.

The joint between Sections Nos. 44 and 45, showing the greatest movement, was filled with bituminous concrete, while that with the next greatest movement (considering thickness) was filled with Portland cement grout. All other joints had corrugated metal, without dowels between the sections.

The two joints showing the least movement are those between the two monolithic sections, 38 and 37, and between the monolithic and concrete sections, 40 and 39.

This table shows very clearly the decrease in observed deflections and total movements during the day and, while the percentages of distribution are but approximate, they show clearly the increased contact during the day. In daytime, for all sections observed, the average deflection was .026 in. less, the average rubbing distance was .039 in. less and the per cent distribution of load across the joint was 8.8 greater than at night. The night observations show but 7 joints offering 40 or more per cent distribution, while during the day 11 show this condition. Comparing both the observed values and those computed for the condition that adjacent slabs have perfect contact, it can be noted that—

1. The difference in computed deflections between night and day was considerably less than in the observed deflections. The computed difference for corners acting independently was .039 in.; that for the observed deflections .026 in. and that for assumed perfect contact but .017 in.

2. On Oct. 25 the average deflection for a 7,150 lb. load at night was .059 in., while for 3,340 it was .017 in., indicating that deflections did not vary directly as the load. This difference in day for the two loads again is different, being .042 in. for 7,150 lb. and but .009 in. for the 3,340 lb. load. That is, at night a 53 per cent load reduction shows 71 per cent less deflection, and during the day the same load reduction is accompanied by 79 per cent reduction in deflection.

The distances through which the influence of the wheel load was exerted ranged from 16 to 26 ft., but because of the different percentages of load acting, no definite compari-

T A B L E I.

TABLE SHOWING OBSERVED AND COMPUTED DEFLECTIONS OF SLAB CORNERS ADJACENT TO JOINTS.

Section			Oct. Night Obs. Deflection				Oct. Day Obs. Deflection.				Inc.	Dec.	Computed equal deflections for both slabs at joint					
			Load on Near side	Load on Far Side	% Load carried across joint	Total movement of corners	Load on Near side	Load on Far side	% Load carried across joint	Total movement of corners	% Dist. Day & Night	Total Move. Day & Night	Rear Wheel.			Front Wheel.		
No.	Thick.	Kind											Night	Day	Diff.	Night	Day	Diff.
40	9"	Conc.	.081	.024	13.0	.111	.040	.019	35.0		22.0							
40	9"	Conc.	.066	.012	26.0		.042	.021	30.0	.042	4.0	.069	.046	.031	.015	.016	.008	.008
40	9"	Conc.	.041	.040	49.0	.002	.035	.035	50.0	.0	1.0	.002	.040	.035	.005	.009	.006	.003
39	8"	Mono.	.040	.039	49.0		.035	.035	50.0		1.0							
42	8"	Conc.	.078	.037	43.0	.061	.030	.030	50.0	.0	7.0	.061	.047	.030	.017	.011	.007	.004
43	7"	Conc.	.050	.030	26.0		.030	.030	50.0		24.0							
53	7"	Conc.	.075	.026	15.0	.104	.055	.026	18.0	.062	3.0	.042	.046	.038	.008	.016	.008	.008
53A	[illegible]	Conc.	.070	.015	29.0		.047	.014	38.0		9.0							
44	7"	Conc.	.094	.004	11.0	.187	.060	.011	18.0	.109	7.0	.079	.057	.040	.017	.016	.007	.009
[illegible]	5"	[illegible]	.106	.009	[illegible]		.076	.016	15.0		10.0							
[illegible]	7"	Mono.	[illegible]	[illegible]	50.0	.00	.037	.037	50.0	.00	0.0	.00	.045	.037	.008	.012	.008	.004
[illegible]	[illegible]	Mono.	[illegible]	.045	50.0		.037	.037	50.0		0.0							
[illegible]	[illegible]	Conc.	[illegible]	[illegible]	47.0	.082	.048	.043	41.0	.011	6.0	.071	.070	.044	.026	.025	.011	.014
[illegible]	[illegible]	Conc.	.092	[illegible]	[illegible]		.044	.038	46.0		26.0							
51	[illegible]	Conc.	.114	.095	20.0	.061	.076	.059	28.0	.046	8.0	.015	.098	.066	.032	.028	.018	.010
50	[illegible]	Conc.	.105	.063	33.0		.079	.050	44.0		11.0							
52	6"	Conc.	.094	.053	15.0	.115	.086	.050	49.0	.101	35.0	.012	.078	.057	.031	.024	.015	.009
51	6"	Conc.	.101	.027	46.0		.073	.008	46.0		0.0							

NOTE: Equal deflections of both corners at joints indicates perfect contact or 50% distribution.

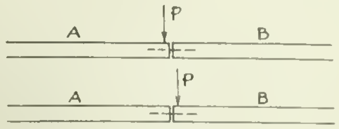
sons could be made. In general, the deflections observed in August agreed with those of October, in some cases being slightly greater and in others being slightly less. The computed deflections for March were but slightly greater than the October. The average of total movements in March were slightly less than in October.

The observations taken in April showed less deflections and slightly greater movement between slabs than those in March or October. Since these readings were taken after 1,600 applications of the truck loads, it would indicate that the effect of traffic loosened the joints somewhat and also caused the surface to have increased subgrade support.

Subgrade Support as Indicated by Pressure Cells.—The influence curves secured from pressure cells placed in the bottom of the pavement were similar to those derived from the Ames dial readings showing the deflections of the various sections, thus indicating that a definite relation existed between deformation of subgrade and its corresponding supporting power. In other words, for the type of soil under the Bates Road the term "supporting value of so many pounds per square inch" is intelligible only when the deformation of soil accompanying such pressure is known. For this reason, the term "pressure in pounds per square inch for a definite amount of deformation" is used in the following discussion.

Relation Between Subgrade Pressures and Surface Deflation.—The relations between subgrade pressures and deflections of the surface are clearly shown by the curves in Fig. 4. Curves No. 31 (3½-in. concrete base, 1-in. sand cement cushion, 3-in. lugless brick, grout filled) for day and night show this relation for corners having little contact. At both times the pressure curves are identical with the deflection curves. The upward warping at night, again, can be noted Pressure without load during the day was .1 lb. per square inch, while at night this pressure was not attained until the corner was deflected .003 in. The maximum pressure at night was .1 lb. greater than that at day, being 3.9 instead of 3.8 lb. per square inch. The corresponding deflection at night was .004 in. greater than at day, being .047 rather than .043 in. Subtracting the initial deflection noted above of .003 in., there results an indicated increase of pressure of 1 lb. per square inch, for an increase in corner deflection of .001 in. Since the deflections of the slab at the pressure cell location (on the diagonal 2 ft. from the corner) were somewhat less than those recorded at the corner, it would seem that the supporting value of the soil under the cell at this time was somewhat greater than 1 lb. per square inch for each .01 in. deformation. The moisture content was 31.5 per cent.

Curves No. 37 (monolithic, 3-in. brick top, 3-in. concrete base) night and day, show the relation between pressure and deflection as found at a joint where perfect contact existed between the adjacent sections. In this case the pressures both night and day without load were 0. With load the pressure at night was .5 lb. greater than during the day, being 2.3 instead of 1.7, while the increase in deflection



Let a_1 = deflection of slab A when load P is on slab A
" b_1 = " " " B " " " " " A
" a_2 = " " " A " " " " " B
" b_2 = " " " B " " " " " B
" f_A = " " " A when slab A takes entire load P
" f_B = " " " B " " B " " " "

Then

$$\frac{a_1}{f_A}\cdot P + \frac{b_1}{f_B}\cdot P = P$$

$$\frac{a_2}{f_A}\cdot P + \frac{b_2}{f_B}\cdot P = P$$

or

$$\frac{a_1}{f_A} + \frac{b_1}{f_B} = 1 \quad \text{--------} (1)$$

$$\frac{a_2}{f_A} + \frac{b_2}{f_B} = 1 \quad \text{--------} (2)$$

from which

$$f_A = \frac{a_1 b_2 - a_2 b_1}{b_2 - b_1} \quad \text{---} (3)$$

$$f_B = \frac{a_1 b_2 - a_2 b_1}{a_1 - a_2} \quad \text{----} (4)$$

If perfect contact exists between slabs A and B, load P produces equal deflections in both slabs, or $a_1 = b_1 = a_2 = b_2$ Substituting values for f_A and f_B in equations (3) and (4) in equation (1) or (2), the deflection

$$f_{AB} = \frac{a_1 b_2 - a_2 b_1}{(a_1 - a_2) + (b_2 - b_1)} \quad (5)$$

in which a_1, a_2, b_1 and b_2 are the observed deflections

Fig. 3.

TABLE II

PRESSURES OBSERVED UNDER VARIOUS PAVEMENT SECTIONS

Section			Cell		Without Load					7150 Wheel Load					Maximum observed without load
					October		August		April	October		August		April	
No.	Thick	Kind	No.	Location	Night	Day	Night	Day	Day	Night	Day	Night	Day	Day	
40	9*	Conc.	8	Corner	0	0	0	0	1.1	0	0	.2	.6	2.7	0.8
42	8	"	14	"	0	0	0	0	0.	0	0	0	0	0*	0
44	7	"	16	"	0	0	0	0	0	0	0	0	0	2.2	0.4
63B	7	"	25	"	0	0	0	0	0	0	0	0	0	0	
47	6	"	17	"	0	0	0	0	0	0	0	0	0	0	1.1
51	6	"	18	"	0	0	0	0	0	1.9	2.2	1.4	.2	0	0
52	6	"	19	"	0	0	0	0	0	.1	.1	.1	.1	1.3	.4
31	8	Semi-Mono.	1	"	0	.1	0	.3	0	3.9	3.8	2.6	2.7	0	.4
35	6	Mono.	3	"	0	0	0	0	0	0	0	0	0	1.8	.5
37	6	"	5	"	0	0	-	0	.1	2.3	1.7	-	.2	3.6	4.5
39	8	"	6	"	0	0	-	-	1.4	0	0	-	-	3.2	0
5	12	Br.on Mac.B	29	"	1.7	.4	-	1.8	.2	18.2	26.6	-	28.0	31.0	
40	9	Conc.	7	Center	0	.1	-	.1	0	.2	.7	-	.1	0	2.1
42	8	"	9	South Side	0	0	0	0	0	0	.3	0	0	.4	.7
			10	S.1/4 Pt.	1.7	-	1.7	.3	0	3.4	-	3.0	2.7	1.2	4.2
			11	Center	0	.1	0	.3	0	.5	.8	.6	1.1	.5	1.3
			12	N.1/4 Pt.	0	0	0	0	0	0	0	0	0	0	.9
			13	N. Side	1.4	1.8	-	2.7	2.2	4.9	4.8	-	5.6	4.9	8.7
63B	7	"	26	S.1/4 Pt.	.9	0	-	.1		1.8	.7	-	.8		
44	7	"	15	Center	1.0	.7	.7	.3	.5	1.6	1.4	1.7	1.5	1.3	1.6
52	6	"	20	"	0	0	-	0		2.0	1.3	-	4.9		3.1
56	6	"	21	" *	.9	1.4	1.9	2.8	2.3	4.5	4.5	5.7	4.8	4.3	4.0
			22	" **	.1	.1	1.9	2.3	2.7	4.6	4.0	6.7	5.6	5.2	7.0
35	6	Mono/	2	"	0	0	0	0		0	0	0	0		5.7
37	6	"	4	"	0	0	0	0	0	0	0	0	0		2.8

* Cell in sub-grade 6" below bottom of pavement.

** Cell on sub-grade at bottom of pavement at night was .008 in. greater than during the day, being .042 rather than .031 in. In these curves it was indicated that after the pressure exceeded 1 lb. per square inch the bearing value of the subgrade was similar to that noted for 31; that is, somewhat greater than 1 pound per square in. for each .01 in. deformation. The moisture content was 29.2 per cent.

Curves 42 show the relation between pressure and deflection at a point 18 in. from the north side edge of an 8-in. concrete section. Again the similarity between the two is very noticeable. With a deflection of .02 in. there was a pressure increase of 3.4 lb., indicating that the bearing value of the soil was about 1.7 lb. per square in. for each .01 in. deformation. The moisture content of the soil was 31.2 per cent. In these curves the influence of the front wheel, as well as that of the rear, is very noticeable. The increase in pressure due to the front wheel (.8 lb. per square inch) was about 25 per cent of that caused by the rear wheel (3.4 lb. per square in.), which relation is similar to that noted above as existing between the corresponding deflections at the corners of the slabs.

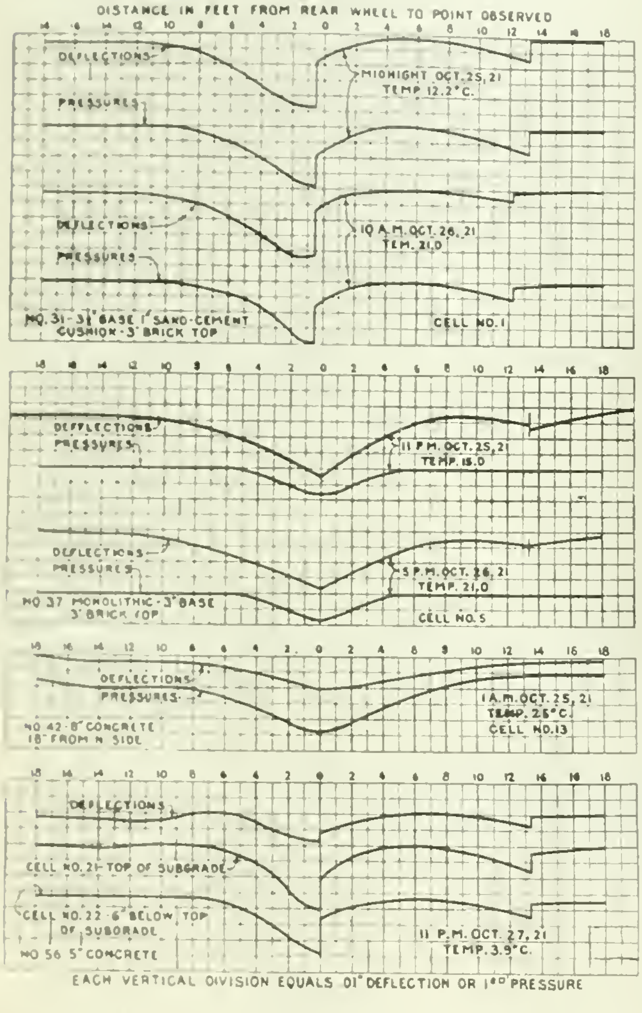


Fig. 4—Curves Showing Relations Between Subgrade Pressures and Deflections of the Surface.

In curves 56 (5-in. concrete) are compared the surface deflections observed with the pressures as shown at the top of the subgrade, as well as those found 6 in. below the top. There is little difference between these two pressure curves except that the one for the top of the subgrade seems to be somewhat more sensitive to surface deflections than the one 6 in. below. A slightly greater pressure is shown for the former than for the latter. When the rear wheel exerts its greatest influence upon the point of observation the bearing value at the top of the subgrade is 2.2 lb. per square inch for each .01 in. deformation, while for a point 6 in. below the top, the increase in pressure is but 1.8 lb. for each .01 in. deflection of the surface. That this cell is close to a transverse crack in the surface is very clearly shown by the curves, the lower pressures seem to increase .1 lb. per square inch for each .01 in. deflection of surface. The moisture content is 29.2 per cent.

Observed Pressures Under Various Pavement Sections.—In Table II are given locations of cells and pressures observed with and without wheel load. It will be noted that in a considerable number of cases no pressures were recorded. This can mean neither that there was no contact between the subgrade and the surface or that the cell did not record such contact as existed. Considering the second possibility there have been cases in which poor manipulation of the cells has created permanent deformation directly under the diaphragm making future readings useless. This, however, can only occur in a soil in which there is little elasticity. For instance, if too great an air pressure is allowed to enter the cell the diaphragm can be pushed down a minimum of something less than .05 in. If the soil has no elasticity a permanent deformation at this point is caused which indicates no contact for future readings. The soil under the Bates Road, however, is extremely elastic. Experiments have shown that under pressure this soil can be deformed .1 in. repeatedly, returning always to its original shape. Also each cell given in Table II has been tested by suction and found to be in perfect working order. It is, therefore, believed that in most cases the zero readings indicate lack of support at the observed points. It will be noted also that many more zero readings were found at corners than at other parts of the sections. For instance, of the 44 corner observations made without load, but 5 showed contact, while out of 47 readings taken at other parts of the slabs without load 24 showed contact. Under the 7,150 lb. wheel load, 18 out of 42 corner points showed contact, 32 out of 47 observations at other points indicated the same condition. From these figures it would seem that especially under corners subgrade support under a rigid pavement is extremely variable. Whether the lack of contact between surface and subgrade was local, being only at the cell position, or whether it extended some distance around the cell position was not determined. If, in addition to the daily warping of slabs caused by temperature change, there is a gradually progressive warp caused by the fact that the top of the slab is more or less dry, being subjected to the air and sunshine while the bottom is in contact with the moist subgrade, the lack of support at the corners would be accounted for.

Upward Warping of Slab Edges.—Considering the pressures with the observed deflections, the upward warping of the edges of the slab at night was again very apparent. For instance, cell No. 8 under the corner section No. 40 from readings taken Aug. 8 indicated that at night .061 in. corner deflection was required to bring the cell location in contact with the subgrade, while in the daytime support at this point was shown by a corner deflection of but .017 in., from which it would appear that distance between subgrade and surface at night was considerably greater than in daytime. Also, for securing contact under the cell in Section No. 51 in October, a corner deflection of .037 in. was required at night and but .010 at noon; while in August, .014 was required at night and but .005 in. in the daytime, indicating again the difference in separation between day and night.

The greatest pressures were observed under Section No. 5, cell 29 (8-in. macadam base, 2-in. mastic cushion, bituminous filled 3-in. lugless brick top). As could be expected, pressures were indicated without load as well as with load. The maximums under load were 18.2, 26.6, 28 lb. per square inch, being about five times as great as any pressures observed under the rigid type of pavement. Also, the distance through which the load was distributed in this case differed from all the others, being but 4 ft., while as noted before with the rigid types, this distance ranged from 16 to 26 ft. The increase in pressure of 16.5 lb. in October was caused by a surface deflection of .147 in., while the increase of 26.2 lb. in August was accompanied by deflection of .287 in. These deflections observed on the surface at the side of the wheel were without doubt somewhat smaller than those which occurred directly under the wheel, thus indicating again that the resistance or bearing value of the soil was something greater than 1 lb. per square inch for each .01 in. deformation.

Of the 12 corner cells which registered more than 1 lb. per square inch pressure, 9 consistently showed support somewhat in excess of 1 lb. per square inch for each .01 in. deformation. Seven cells recording less than 1 lb. per square inch indicated no relation between pressure and deflection. This bears out the result of previous experiments from which it was indicated that after initial pressure had been applied the soil had a definite bearing value.

Deflection at Different Points in the Slab.—A very interesting condition of support was found under Section No. 42 in which the cells Nos. 9, 10, 11, 12 and 13 were placed respectively 18 in. from the south side, 4½ ft. from the south side, in the center, 4½ ft. from the north side and 18 in. from the north side. Without load at night, support was indicated only under the quarter point on the south side and the 18-in. point on the north side; during the day in addition to the above locations, slight support was indicated also at the center. Under load there was no support indicated either for the 18-in. point on the south side or the quarter point on the north side, but on the 18-in. point on the north side about 5 lb. was shown, on the quarter point on the south side about 3 lbs. and but .6 lb. in the center. With support of this kind the cracking of a pavement under load can easily be understood. In every case the pressure shown by cell 11 in the center is greater in the daytime than at night, thus indicating greater deflection at the former time. Since from previous experiments it was indicated this condition of increased center support can occur only with the presence of a longitudinal crack or joint, an inspection of the section was made and such a crack was found.

Observations on slab 42 also furnish information on the relation between the deflection occurring at different points of the slab. The greatest deflection noticed in the center of the slab was .006 in. That at points 18 in. from the sides of the slab .020 in. That at the corner, under best conditions of contact, .040 in. And that computed for corner without any contact with adjacent slabs .080 in. If deflection is an indication of stress, the corners apparently are the least resistant parts of the slabs. The cell readings taken on April 17, 1922, after 1,600 applications of traffic load indicated that support at the corners was slightly better than that found before the traffic was started.

General Observation.—General observations to be made from the foregoing results are:

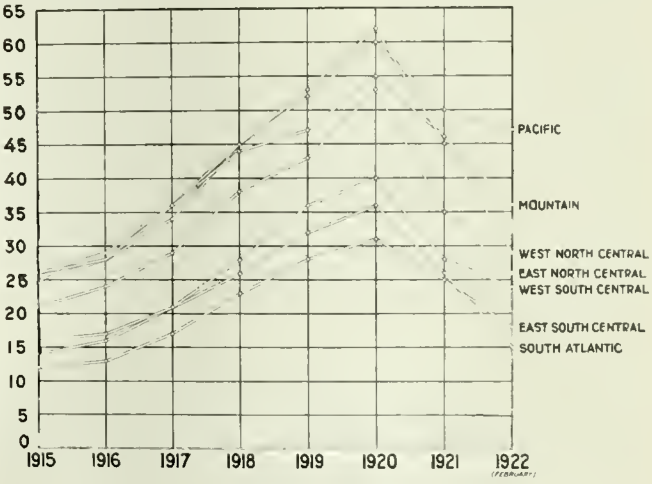
1. That after initial pressure has been applied the soil had more or less definite bearing value, being slightly greater than 1 lb. per square inch for .01 in. deformation under the Bates Road. Also that the supporting value of the soil apparently was less in March than in either August or October.
2. That the support under a rigid surface is extremely variable, indications being that the surface rests on small mounds of the subgrade, having little or no support in other areas.
3. That the condition of least support is found under the corners of sections. This support, however, was improved by traffic action.
4. The distance through which the influence of the load was felt on an 8-in. macadam base was much less than that on an 8-in. concrete while the corresponding pressure on the former was about five times as great as on the latter, indicating that a soil of much higher supporting value is required for a pavement on an 8-in. rolled stone base than is required for an 8-in. rigid type of pavement. The pressure exerted on the subgrade could be reduced by increasing the thickness of the rolled stone base.
5. That the effect of temperature change is very noticeable in rigid pavements, causing both warping and longitudinal expansion and contraction. The effect of this temperature change was least in two joints, one between two monolithic sections and one between a monolithic and concrete section
6. That the deflection of an independent corner was about 13 times, and that of a confined corner about 6½ times that found at the center of the slab, indicating that the corner is the part of the slab which most deserves investigation.
7. That neither the pressures nor the deflections as observed at corners varied directly with the magnitude of the load.
8. That considerable movement can occur between the edges of adjacent slabs when there is not perfect contact between them, this movement being the cause possibly of shattering the edge, feathering about the joint. That this movement is slightly increased by traffic.
9. That if perfect contact can be secured between adjacent edges of slabs, all movements between them will be eliminated, the deflections will be lessened and the effect of warping between night and day will be considerably reduced.

From the foregoing it would seem that every effort should be made to devise means by which sections of pavement can be so tied together that movement between them will be eliminated, or in the absence of connection between sections at joints, special designs should be used for increasing the resistance of the corners.

Common Labor Wages in Road Building

The accompanying chart prepared by the Bureau of Public Roads of the United States Department of Agriculture showing the trend of common labor wages on highway construction in various geographic divisions since 1915 presents an interesting study of conditions during the period. The price per hour which in 1915 ranged from 12 ct. to 26 ct., gradually rose to from 31 to 62 ct. in 1920 and has now declined to from 15 to 47 ct. In May the prices were as follows: 15 ct. in the South Atlantic States, 18 ct. in the States east of and bordering the Ohio and Mississippi River and including Alabama, 24 ct. in the Texas, Arkansas, Oklahoma and Louisiana group, 26 ct. in the states included between the Ohio and Mississippi Rivers, 29 ct. in the States from Kansas and Missouri to the Canadian border, 36 ct. in the Mountain States and 47 ct. in the Pacific States. Figures for the New England and Middle Atlantic States had not been completed but it is thought that they will run about with the average for the other Staes.

On the diagram the lines showing the trend in the various divisions have the same general rise and fall and cross each other in only a few cases, a particular exception being in the States from Kansas and Missouri north to the border, where the highest rate of all the groups prevailed up to 1920 and which has since shown the most marked decrease, dropping from 62 ct. in 1920 to 29 ct. in March.



Trend of Common Labor Wages in Highway Construction by Geographic Divisions.

State Brick Road Construction in Illinois and Indiana.—Contract for construction of the first brick road to be built by the state of Illinois since Governor Small's "$30,000 a mile" edict went into effect, was let early last month by the Illinois State Highway Department. While smaller political units in the state have been building brick roads, this is the first action of its kind on the part of the state highway department under the present administration. The contract was let to J. E. Craine of Murphysboro, Ill., the work covering 13.32 miles on Route 2, sections 12 and 13, extending from Cobden to Dongola, Ill. Specifications provide for a base of 10 in. of novaculite, laid in two 5-in. courses, a 1½-in. sand cushion, 3-in. vitrified brick and asphalt filler. The pavement will be 18 ft. wide. Indiana early in May let a contract for the construction of the first brick road in Indiana to be built under the direction of the State Highway Department. Indiana was one of the last states in the union to establish a highway department, and while many miles of brick roads have been constructed in the past by the various counties, this contract was the first action of this kind by the state. The section to be paved with brick is 6.897 miles long and extends from Putnamville to a point 1½ miles east of Mt. Meridian. The design calls for 5-in. concrete base, 3-in. vertical fiber brick and asphalt filler. The work will be done by the Carpenter Construction Co. of Terre Haute.

Field Testing of Materials in Highway Construction

Some interesting points on the various features of controlling the quality of materials used in highway construction and maintenance were brought out by John H. Bateman, Director Michigan State Highway Laboratory, in a paper presented at the 8th annual conference on Highway Engineering at the University of Michigan. An abstract of that portion of the paper relating to testing in the field follows.

The testing of materials in the field is naturally confined to those tests for which equipment may readily be manufactured which is comparatively inexpensive and easy to transport and to those tests which do not require strict conditions of temperature or methods of analysis which can only be carried on in an enclosed room under exacting conditions. The testing of such material as Portland cement is a laboratory process. Sand, gravel and crushed stone may, however, be examined in the field with a good deal of efficiency.

Sand Tests. The testing of sand in the field is of considerably more importance than is generally recognized, both in connection with preliminary tests and with the control of materials from known sources of supply. The tests which are ordinarily conducted on sand are tests to determine cleanness, both as to organic matter and clay, size and grading, and strength in mortar. The latter test is essentially a laboratory test. The size and grading of sand may readily be determined by a set of field screens and sieves. The determination of quantity of clay and silt in sand may readily be made in the field on a volume basis by selecting a sample of the material, mixing it thoroughly, and cutting it down to a size suitable for testing. This small sample is then placed in a graduated glass cylinder together with water, and the whole vigorously agitated without whirling. The per cent of clay and silt, by volume, may then be determined by measurement of this material which is in the upper part of the cylinder and which may be readily noted by the eye.

Determination of Organic Matter in Sand.—It is the writer's opinion that the determination of organic matter in sand is one of the most important tests that may be applied to this material. The relationship between organic content and decrease in strength of both mortar and concrete has been quite definitely determined, and the low strength of concrete, in many instances, may be traced directly to this particular feature of the sand. Small variations in the properties of Portland cement and other features of aggregates are of insignificant importance if organic matter is present in the sand in any considerable quantity. Fortunately this quality of sand may be determined in the field by a comparatively simple method.

The test as it is usually made, consists of thoroughly digesting the sand with a 3 per cent solution of sodium hydroxide and observing the resultant color of the liquid above the sand after the mixture has been allowed to stand for a few hours. The procedure may be briefly described as follows: a 3 per cent solution of sodium hydroxide may be made up by dissolving 1 ounce of sodium hydroxide (obtainable at any drug store), in enough water to make 32 liquid ounces. Fill a 12-ounce graduated prescription bottle to the 4½ ounce mark with the sand to be tested, add the 3 per cent solution of sodium hydroxide until the volume of the sand and the solution, after shaking, amounts to 7 ounces. The mixture should be shaken very thoroughly and allowed to stand for 24 hours. If the solution resulting from this treatment is colorless, or has a light yellowish color, the sand may be considered as practically free from organic impurities and satisfactory for use insofar as this quality is concerned. If, on the other hand, a dark, brown colored solution is obtained, the sand should not be used for concrete aggregate. The time indicated above, of 24 hours, is usually the standard time allowed for settlement of the solution. A very good idea of the character of the sand, however, may be obtained in a much shorter period.

The size and grading of gravel and crushed rock may be obtained very easily by means of a compact set of field screens and sieves.

Tests of Water for Concrete. Occasionally one desires to use a source of water for concrete which appears questionable. While it is true that in this state we seldom encounter unsatisfactory supplies of water, nevertheless, simple tests can be made in doubtful cases to determine whether any supply is objectionable. Strips of red and blue litmus paper (which may be obtained in any drug store) can be used by inserting them in the water for a period of five minutes and noting the color produced. A marked reversal in color indicates the presence of acids or alkalis, and makes further laboratory tests advisable. Laboratory tests usually consist of determination of total solids and quantity of organic matter present, or a comparison of the given water with a water of known satisfactory quality by making standard tests of a sample of cement which is known to be satisfactory.

Determination of Consistency of Concrete.—An important part of the work of field control of materials is in connection with the control of cement concrete entering into either concrete pavements or other concrete structures such as bridges, culverts, retaining walls and other similar structures. Due to the large amount of investigative work which has been completed in the last two years, we know a great deal more about the importance of certain features in connection with the manufacture of cement concrete than was the case a few years ago.

Time of mixing, method of curing, and the consistency of concrete are now recognized as among the most essential elements affecting the finished product. Time of mixing and method of curing may be easily controlled by the field forces on a construction project. Consistency or the per cent of water in concrete is another item which has often been neglected in the past, but which is now receiving more careful attention on the part of both construction organizations, such as contractors, state and municipal forces. We know, beyond a doubt, that a dry concrete is much stronger than a wet concrete, all other conditions being equal.

Two methods have been devised for determining the consistency of concrete, only one of which is readily adaptable for use in the field. This method is known as the "slump" test and is conducted by placing concrete, fresh from the mixer, in a metal mold, 12 in. high, 8 in. in diameter at the bottom and 4 in. in diameter at the top. This form is placed on a level and preferably a non-absorbant surface, such as a metal plate. The concrete is placed in the open end in approximately three layers, each layer being rodded with a ½-in. or ⅝-in. steel rod, preferably pointed at the end. After the form is filled the rod may be used to strike off the concrete level with the top of the form. The form is then carefully removed by raising it in a vertical direction and the distance which the concrete slumps down, or in other words, the difference between 12 in. and the remaining height of the concrete after the form is removed, generally denoted as the "slump," is considered as a measure of the consistency of the material. The entire apparatus for this simple field test can be obtained at a cost of $2 or $3, and if kept properly cleaned, may be used for several seasons.

Tests of the concrete itself may be conducted in a laboratory by taking specimens for tests of compressive strength, wear or cross breaking strength. Probably the most logical test to use is the one involving the cross breaking strength of the material. This test, however, unless laboratory facilities are provided very close to the work is impracticable on account of the necessarily large size of the specimen and the cost of transporting it to the laboratory. Compressive strength tests or tests for wear have generally been utilized to a greater extent.

State Highway Construction in California.—By the end of present fiscal year California will have completed around 3,007 miles of its state highway program, or about half the mileage incorporated in the state system by the various bond and legislative acts pertaining to highways. In addition to this 3,007 miles are 946 miles of special appropriation roads which are not included in the list of completed highways. The total mileage in the state system for both building and maintenance is over 6,300 miles or close to 10 per cent of all dedicated public roads in the state, exclusive of incorporated cities. Of the 3,007 miles built by the California Highway Commission, 1,765 miles are concrete base roads, with or without asphaltic surfacing, 305 miles are paved roads of other types and 937 miles are graded roads.

How a Street Railway Company Is Handling $1,000,000 Paving Contract

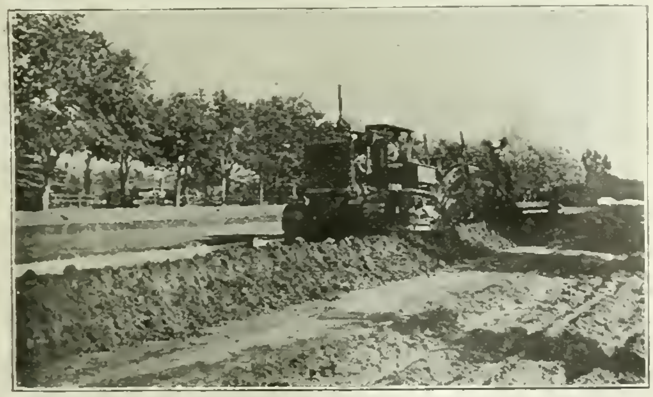
In January, 1921, the city of Colorado Springs, Colo., received bids on one of the largest paving districts ever formed by a city in the west. These bids were finally rejected. There then developed the possibility of The Colorado Springs & Interurban Railway Co., the local street car company, taking the paving contract and the officials were approached by the business men of the city and were finally prevailed upon to bid upon this work at the next letting.

Their reasons for this were twofold. First, that the company was the largest single taxpayer in Colorado Springs and was accordingly interested in as economical a procedure as possible, and, secondly, they believed they might effect a considerable saving to the city of Colorado Springs if they were to attempt to do the work at cost.

A plan was finally adopted under which the company filed a bid at the next letting, attaching thereto a supplemental agreement whereby all the necessary equipment purchased by it to do the work, together with all profits accruing from the performance of the contract, were, upon completion of the contract, to revert to and become the property of the city of Colorado Springs.

The company's bid was $5,000 lower than the next low bid and the contract was awarded to it on June 24, 1921. The contract involved the following approximate quantities:

Two hundred and fifty-three thousand sq. yds. of 2-in. asphalt wearing surface, Topeka mixture, laid on a 5-in. concrete foundation, 1:3:5 mix; practically 90,000 cu. yd. of excavation, 100,000 lin. ft. of curb and gutter, 10,000 lin. ft. of 10-to 36-in. storm sewer, which, together with other incidental items, made the total value of the work to be done approximately $1,000,000.



Holt Caterpillar and Austin Rip-Snorter Scarifying and Piling Up Earth in Windrows.

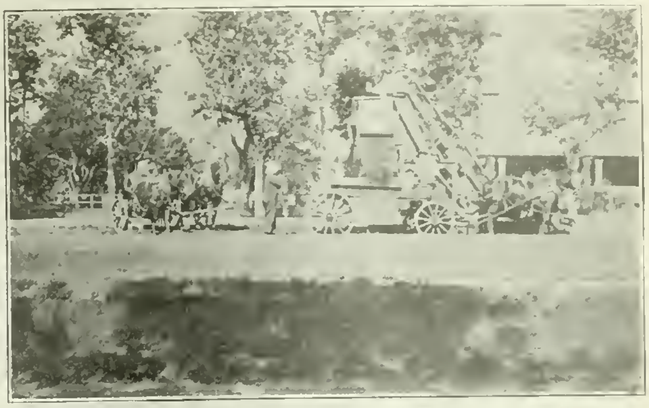
At the time the award was made The Colorado Springs & Interurban Railway Co. was without organization or equipment of any description for work of this kind and was forced to immediately purchase the necessary machinery and to develop an organization. This was done. At the end of 1921 season the company had accomplished approximately one-half of the entire contract.

Excavation.—In view of the light average cut which prevailed over the entire paving district of approximately 6 to 7 in., it was decided to excavate by the following method and with the following machinery:

One 10-ton Holt Caterpillar, an Austin Rip Snorter combination scarifier and blade machine and two Barber-Greene bucket loaders. The scarifier and blade machine, together with the Holt tractor, piled the earth in long windrows about 5 ft. wide and 30 in. high, after which the B-G loaders elevated the dirt into wagons. The scheme has worked out very successfully and approximately 42,000 cu. yd. of earth were excavated last season, all labor, cost of excavating and fine grading, as well as repairs, interest and depreciation, running about 90 ct. per cubic yard.

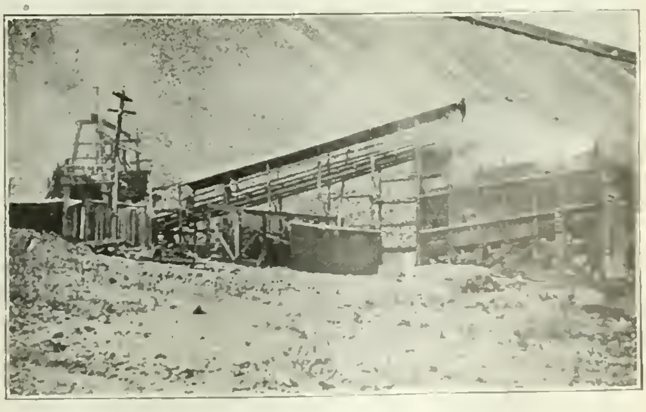
Concreting Operations.—The central concrete mixing plant system was used for concrete foundation, the plant being erected adjacent to the asphalt plant. Both fine and coarse aggregates were maintained in bins of approximately 650 cu. yd. capacity, the bins being constructed underneath a railroad trestle where material was received in steel bottom dump cars and emptied directly into bins. Aggregates were conveyed from underneath these bins by means of a conveyer belt to a double elevator which carried the material up to an auxiliary 20 cu. yd. bunker. This in turn discharged directly into the measuring batch hopper, where in turn the material was fed directly into a 27 cu. ft. Smith tilting mixer.

Cement was received in carloads on the same trestle and unloaded directly from cars to batch hopper by gravity chute. When the plant was not in operation cement was conveyed to storage warehouse by gravity chute from same car location. The warehouse had a capacity of approximately 10 carloads and was kept filled up to its capacity as much as possible. When the plant was in operation and without cars of cement on the track, cement was delivered to the batch hopper by means of an inclined conveyor belt from the warehouse. The same labor handled cement in either event. The total mixing plant labor costs were 3½ ct. per sq. yd.; costs of power, repair parts, maintenance, interest and depreciation were 2½ ct. per sq. yd. The mixing plant operated 52 days, from Sept. 2 to Nov. 6, and laid approximately 120,000 sq. yd., an average of over 2,300 sq. yd. per day. The work day averaged 9 hours. The biggest day's run was 419 cu. yd. The average mixing time was 1 minute and 20 seconds. The average haul was 2 miles. The largest number of trucks used was ten 3½-ton trucks and four 5-ton trucks. The plant operated through the season with practically no delays. The cost of street labor for laying the 5-in. foundation was 4½ ct. per sq. yd. No particular trouble was experienced in operations or results on the long hauls or emptying the concrete from the trucks.



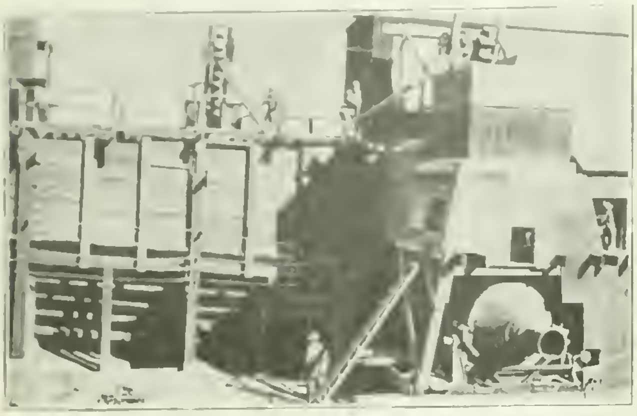
Barber-Greene Loader Picking Up Earth From Windrows.

All of the coarse aggregates for the concrete base and asphaltic surface was crushed rock which The Colorado Springs & Interurban Railway Co. produced from its own crusher and screening plant at Cripple Creek. This plant comprised two No. 5 Allis-Chalmers gyratory crushers and 10x18 jaw crusher and one 36-in. pair of rolls. This plant had a capacity of about 600 cu. yd. of screened aggregate in 8 hours. The entire operating costs of the crushing and screening plant, including all labor, power, repairs, interest and depreciation, was approximately 65 ct. per ton.



Stone Crushing and Screening Plant at Vindicator Dump. A 60 HP. Drag Was Used to Deliver Rock to Crusher. The Dump of Rock Is Estimated to Contain 3,000,000 Cu. Yd.

Asphalt Mixing Operations.—The Colorado Springs & Interurban Railway Co.'s paving department constructed its own asphalt mixing plant, using two old ore roasters 66 in. in diameter, which were extended to 20 ft. in length, and were fed by conveyor belts from the rock and sand bunkers. The roasters were fired by internal combustion fuel oil burners. The heated aggregates were elevated and screened into a 20 cu. yd. steel bunker. This in turn fed in a weight box on a five beam scale, which in turn discharged the material into a 15 cu. ft. pug mixer. Mexican asphalt purchased from the Standard Oil Co. of Louisiana was supplied in tank cars and was run by gravity from the cars into a concrete sump, having a 70,000 gal. capacity. The sump was fitted with sufficient steam-heated coils to maintain the asphalt at a temperature of from 280° to 300° in the heated end of the sump. Asphalt was pumped from this sump direct to the pug-mixer. Limestone dust was used as filler.



Central Mixing Plant.

The cost of the entire asphalt mixing plant erected and ready for operation was a little over $11,000 and during its run last year it turned out approximately 120,000 sq. yd. of 2-in. surface at a cost for all plant mixing labor and all street labor of 12 ct. per square yard. Power, coal and fuel oil, repairs and repair labor, amounted to 7.2 ct. per square yard. Constructing the asphalt wearing surface involved also a liquid seal coat with a stone chip squeegee. Two 8-ton tandem rollers were used and the average specific gravity obtained for the completed pavement was 2.21. The maximum output of the plant for one day was 3,200 sq. yd. and the average maintained through its entire operation last season was approximately 2,500 sq. yd. per 8-hour day.

Some 25,000 lin. ft. of curb and gutter were installed last year as well as nearly all of the required storm sewer work. It is expected that the contract will be completed by the latter part of this summer and the general results from present indications are that The Colorado Springs & Interurban Railway Co. will effect a saving for the city of Colorado Springs of approximately $100,000 in addition to the cost of the equipment by reason of its performance of this paving contract on a cost basis.

Concrete for Base Being Delivered at Extreme Haul of About 3.3 Miles. Also Shows Use of Template and Small Hand Roller to Slightly Roughen Surface.

The work is being done under the direction of Mr. R. H. Kimball, who was retained by the company to take complete charge of the entire proposition, including the selection and purchasing of all the equipment, the designing and laying out of all the plants and methods of construction and the building up of the organization.

The Engineer as a Political Economist*

By HALBERT P. GILLETTE, Editor.

The definitions of economics in the dictionaries and in the books on political economy are not entirely satisfactory because they fail to specify a criterion by which an economic choice between alternatives should be guided. It is not enough to say that economy is the exercise of good judgment in the expenditure of energy, labor or capital. We should be told how to distinguish relative degrees of judgment. I suggest, therefore, the following definition:

Economics is the science that treats of the principles involved in securing a maximum annual income for a given economic unit under given conditions.

The economic unit may be an individual, a partnership, a stock corporation, a nation, a group of nations, or all the nations in the world. Other economic units will suggest themselves.

It is evident from this definition that economy is relative to the given economic unit. What is most economic for an individual may not be most economic for the corporation that employs him. What is most economic for a corporation may not be most economic for the nation. What is most economic for a nation may not be most economic for the world.

If the economic unit is the world, then the "income" in the definition is "gross income," for the conception of "net income" exists only in reference to economic units that trade with one another. But, since nearly all economic problems involve economic units that exchange goods and services, the "income" under consideration is almost always "net income."

There are many kinds of economic problems in which the "gross income" is substantially a constant, in which case the problem is to secure a minimum cost. Thus, in the design of a highway bridge, the gross income to the community is usually constant no matter what kind of a bridge is built, provided it is adequate to carry the prospective traffic. Hence the problem of the engineer is to design a bridge whose annual cost will be a minimum. Most of the economic problems that civil engineers solve are of this nature—problems in minimum cost. Wellington was among the first to teach civil engineers that they must frequently consider their economic problems as being problems in maximum net earnings. His great treatise, "The Economic Theory of Railway Location," is an admirable exposition of methods to be used in solving problems in maximum net earnings. More and more it is becoming the function of engineers to solve problems in which maximum net earnings are the desideratum.

Training for an Economist. The training that engineers have received in solving such problems fits them, above all other classes of men, to solve the broadest of economic problems, namely, problems in political economy. Political economics differ from engineering and business economics only in the size of economic unit, an entire nation often being the economic unit.

If international trade is relatively quite small, as it is for America, then the primary problem is to secure maximum gross income for the people of the nation. The secondary problem is to secure a maximum net income for each worker.

To solve the primary problem a vast number of subsidiary problems must be solved. For example, we must ascertain what is the law that states the quantitative relation between commodity price levels and the factors that affect such levels. Hitherto we engineers have regarded such broad economic laws as not being within our special province. I purpose indicating why we should enlarge our conception of engineering to include political economy.

To begin with, if my definition of economics is correct, no economic problem can be solved until each of the important factors is qualified. This means the application of mathematics. Let me ask you to ask yourselves whether engineers are not more skilled in the use of mathematics in solving a great variety of economic problems than any other large class of men? So-called professional political economists are either teachers or politicians. Teachers of political economy are notoriously poor mathematicians. I could show you some of the most astonishing blunders in mathematical logic in one of the books by one of the best known of these teachers. But most of their economic treatises are noteworthy for the paucity of quantitative data, and the almost complete absence even of an attempt at quantitative solutions of economic problems. Of course politicians are even less inclined to use applied mathematics. Hence it is to be expected that although there is a vast literature on political economics, it is largely worthless. The economic talk is practically all qualitative, although no quantitative problem was ever solved by qualitative methods.

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*Abstract of an address before the Young Men's Forum of the Western Society of Engineers.

If two designers of two bridges over a given river were to argue the economic merits of their respective designs as two political economists argue free trade vs. protection, you would be disgusted. Some of you would probably interrupt the debaters by asking for the estimated costs of the bridges. You would demand a quantitative solution of the problem. But if Bryan were debating "free trade" with Fordney, you would probably ask for no quantitative proof, either because it might not occur to you to do so or because you would know that the request would be barren of results. We have been long accustomed to hearing or reading debates of that character, and of saying to ourselves wearily at the close: "I am afraid this subject is too deep for me." The fact is, however, that we fail to see the bottom of such pools of language not because they are too deep but because they are too muddy.

I urge you not merely to challenge every qualitative argument on every economic subject, but to begin to solve some problem in political economics yourself. The success that has followed my own effort to solve a few such problems convinces me that an engineering training will enable you to accomplish what generations of political economists have not accomplished.

Use Engineering Methods.—Let me cite an example of the advantage that a training in applied mathematics gives. In the two or three attempts that professors of political economics have made to produce a quantitative solution of the general price level problem, they all tried to ascertain the weighted average relative price of commodities, wages and securities (stocks and bonds). If you plot the relative prices of each of these three things over a long term of years, you see at a glance that the commodity price has oscillated widely in 50-year cycles, that the wage curve has ascended steadily, and that the security price curve has oscillated relatively slightly in short cycles. This would lead an engineer to abandon any attempt to plot a composite curve of these three things and to secure a formula therefor, because even if such a formula were derivable it would be useless. What we want is usable formulae. But apparently the professors of economics made no such plots of the three curves, or, if they did, failed to ask themselves what use a composite average would be.

I have ascertained that the formulae for relative commodity prices (price levels or indexes) and for wages are:

(1) $p = \frac{K M V}{P E}$ = commodity price level or index.

(2) $w = \frac{k M V}{P}$ = wage level or index.

K and k = constants.

M = money in circulation, total.

V = velocity or circulation, or rate of money turnover.

P = population.

E = per capita efficiency of production.

These formulae fit the curves of prices and wages very closely as far back as reliable data are available, back to 1840 for wages.

Had I lacked an engineering training I should probably have followed the precedents established by the political economists who have tried to solve the "general price index problem," and I should have failed, for there is "no such thing" as a general price index.

Let me indicate a few of the economic problems that engineers have solved during the past generation.

What Engineers Have Done.—Prof. Hatfield in his "Modern Accounting" gives to engineers the credit for having devised the modern systems of unit cost accounting. Yet accountants and business men had had unit cost problems before them for generations, and had accomplished relatively little.

The science of management is an engineering achievement the inception of which is only 14 years old. In its early stages, when certain engineering periodicals were ridiculing its exponents, the Chicago Tribune said editorially that to the layman it looked as if the science of management was about the biggest thing that engineers had ever developed. Although a vast literature has already come into existence, it is significant that most of it has been written by engineers.

About 17 years ago certain states began to regulate the rates of public utilities. Engineers were employed to make appraisals, but some of them soon began to study the entire problem of rate-making. The result is that practically all the literature in the great field of economics has been written by engineers during the past 15 years.

The mere writing of literature on a subject does not of itself entitle the writers to praise. But it happens that in the case of rate-making literature several important economic problems were solved for the first time correctly. I shall mention only three of these problems. (1) Depreciation; (2) prorating point costs, and (3) development cost. Scientifically correct and perfectly general principles for estimating accrued depreciation and for prorating joint costs are now available, as the result of engineering studies.

That development cost, or the accrued deficit involved in establishing a business, often was great was well known to some business men; but how to estimate it and what it ordinarily had averaged were not known until engineers investigated the matter. Its great economic importance then was made evident.

The problem of when to retire a plant or a plant unit was centuries old, but its correct solution is not ten years old. This solution was an incidental outcome of the study of depreciation by engineers.

Engineers' Fitness for Leadership.—American engineers number more than 100,000. They constitute the only large body of scientifically trained men who are accustomed to treat economic problems as if they were quantitative problems. As scientific men they are accustomed to teach one another, which is not true of the only other large body of practical economists, the "business men." For these reasons and because their training inculcates both honesty and altruism, I believe that engineers are destined to be the future political economists. As city managers they have already made their debut in the field of practical politics, and thus far their successes have markedly exceeded their failures.

Engineering societies are beginning to take an active interest in political matters upon which engineers are competent to express judgment. Eventually they will become the leaders in promoting public works that are economically needed, and in condemning unwise investments in public enterprises. They will secure amendments of laws that obstruct the proper development of public works. They will solve complex problems in the theory of political economy, which they have hitherto regarded as outside the realm of engineering. They will educate the editors of daily papers to an understanding of the great fact that economic problems are all problems in applied mathematics, and that therefore their solution should be entrusted to scientifically trained experts.

States Aid in Eliminating Railway Grade Crossings

What can be done when a community sets out to rid itself of the menace of railroad grade crossings is shown by the plans for a federal-aid road to be constructed in Alabama between Ariton and Clayton. In a distance of about 25 miles the old road crossed the railroad 14 times. By good engineering 13 of these crossings have been eliminated, the remaining one being in the small town of Clio, where there are only three trains a day, and these move at slow speed as they approach the station.

Some months ago the U. S. Bureau of Public Roads announced that grade crossings would be eliminated on all federal-aid highways wherever practicable. Officials of the bureau are receiving hearty co-operation from state highway departments and the general approval of the public.

It has been found possible to revise many plans, keeping the road entirely on one side of the track or finding a suitable place where the road can cross beneath or above the track.

In some states the highway departments on account of existing legislation are having difficulty in inducing the railroad companies to share the cost of placing the highway above or under the track.

Operation and Care of Motor Trucks of New Jersey State Highway Department

In a discussion at the recent convention of the New Jersey Highway Association, Mr Norman C. Applegate, Superintendent of Equipment of the New Jersey State Highway Department, gave some interesting details regarding the handling of the trucks of the department The notes following are reprinted from the March Highwayman

The State Highway Department has a total of 417 motor vehicles, that is, light cars and trucks, and in addition also has approximately 175 other pieces of power equipment, including rollers, tractors, concrete mixers, steam shovels, pumps, etc , under the direct control for care and operation of the Equipment Division.

The Equipment Division acts as a trucking or equipment contractor to the other state divisions, such as maintenance, construction, bridge, etc , and has full charge of maintenance and care and method of operation of equipment. The operators of these vehicles work under the supervision of the various superintendents, foremen and engineers as to hours worked and work done

Control.—Location of every piece of equipment are kept posted on a large map of the state showing the different highway routes. Different colored and size map tacks with the various department numbers printed on them are used to denote different types of equipment. These tacks are spotted on the map as near as possible to the actual place where equipment is located. The map which we use is on a scale of approximately $\frac{1}{2}$ in. to 1 mile. This map is posted within two or three days after changes in location are made. A card system is also kept which gives full information regarding the piece of equipment together with the dates the locations of same are changed.

Operation.—In our work the season is about seven or eight months long and outside of a few isolated cases the truck would not be in one location on the average for more than three or four months. This makes it difficult to procure and keep competent drivers. Practically every time that the location of a truck is changed it becomes necessary to change drivers, due to the fact that the older men object to working away from home and the short season. Most of the drivers want the all-the-year-round outside work and object to being placed in the shop throughout the winter season.

Vehicle Inspection.—Our inspection was taken care of in the past year by one inspector, who covered the entire state. He was able to make the trip once in two weeks. This inspector's duties were as follows: To inspect and make a report as to care taken of equipment and method of operation and report same to the equipment office; also to make whatever minor adjustments were necessary. He did not, however, do any repair work on these trucks, but in cases where he found it necessary he would phone the central garage, Trenton, and a service mechanic with repair parts would be sent out to take care of the trouble. This year, on account of additional equipment in use, we are planning to divide the state into four districts, each of which would contain between 150 to 200 miles of state highway. One mechanic, or, if necessary, mechanic and helper, would be assigned to each one of these sections to make all necessary inspections and repairs on equipment. They would be held responsible for all equipment in their territory. Only in cases of extraordinary trouble, such as serious motor or transmission trouble, where it was necessary to bring the unit into the shop for repairs, would the garage forces be required.

Repairs.—We have one central repair shop which is located at Trenton. Practically any part of the state can be reached by a service man with parts necessary within three or four hours at the most from here. Sufficient stock is carried at our central service station to take care of all except extraordinary repairs on all types of equipment which we operate, except touring cars, on which we can get service at several different places in the state. Our equipment is tied up practically throughout the entire season. While not actually working during the four or five months in the winter, when they are taken off the road work, these trucks, immediately after the road season, are brought into the garage and equipped with snow plows and sent out and kept available at all times for snow removal. Until the present season we have not had enough equipment "as reserve" to enable us to replace equipment out on snow removal while these trucks were being overhauled.

Parts are carried in our service station for all makes of trucks. We have not found it practical to depend on Philadelphia or New York stock for truck repair parts, as in several instances we have found it necessary to secure these from factories located several hundred miles from Trenton.

Accounting.—At present our accounting and costs are distributed in a general way as follows:

Operation of Trucks.—This means that operating costs for all trucks are lumped together with no distinction made between different makes and sizes. In like manner, all other equipment is lumped, that is, all costs for steam shovels, mixers, road rollers, pumps, etc., are grouped under the general head, "Operation of Equipment," and it is not possible to segregate different types and makes of equipment. It is my opinion that individual costs should be distributed as follows:

Inside repairs,
Outside repairs,
Gas and oil,
Tires,
Operators' salaries,
Operators' expenses.

The above should be compiled for each piece of equipment each month. This information is necessary for the intelligent working of equipment.

Tire Record.—At present tires are furnished to us under competitive bidding. In the past very few tire records have been kept due to the fact that the adjustment which we were able to get under the agreement under which the tires were bought, made the cost of keeping records of tires equal or more than actual benefits that we received from any adjustments.

Plans for 1,170 Miles of Forest Highways Approved

A program of national forest highway construction involving an outlay of over $10,000,000 for 1,170 miles of road in 23 states has been approved by Secretary of Agriculture Wallace. This program will be financed largely from the forest highway fund provided by the federal highway act. About $6,500,000 will come from this source, $1,000,000 from other national forest road appropriations, and the balance of $2.500,000 will be contributed by states and counties.

The work provided for is as follows:

State.	Proposed expenditure.	Miles.
Alabama ....$	3,953	15
Alaska	896,850	55
Arizona	1,011,500	133
Arkansas	142,796	23
California	1,246,197	50
Colorado	627,000	105
Florida	91,175	14
Idaho	1,269,600	137
Montana	566,421	75
Nebraska	9,958	22
Nevada	166,000	24
New Hampshire	29,288	5
New Mexico....	452,000	64
Oklahoma .....$	4,572	3
Oregon	2,270,000	210
South Carolina.	2,173	5
South Dakota..	61,000	7
Tennessee	15,000	3
Utah	292,100	56
Virginia	20,000	4
Washington ...	780,000	50
West Virginia..	4,901	20
Wyoming	260,150	90
	$10,222,634	1,170

The funds and mileage are for forest roads of primary importance to states, counties, and communities. The program was recommended to the Secretary by the U. S. Forest Service and the Bureau of Public Roads, jointly, after conferences with state officials. The Bureau of Public Roads will supervise the construction work, and it is expected that a large number of the projects will be completed this season.

Practically all the roads to be built are parts of the state or county highway systems and will therefore in most cases connect with and extend the system of federal-aid highways covering the whole country. In some cases the new construction will provide roads through mountainous regions of the national forests hitherto penetrated only by pack trails.

In addition to the major road projects, about $5,000,000 will be expended by the Forest Service on minor roads and trails required primarily for the protection and administration of the national forests.

$15,000,000 for Street Railways in New Orleans.—Rehabilitation of the properties of the New Orleans Railway and Light Co. is to be undertaken at once according to press reports. For this purpose, the sum of $15,000,000 will be expended over a period of 5 years—one third of it in the first year.

Highway Marking System of State of Illinois

By RALPH R. BENEDICT,

Assistant to Chief Highway Engineer, Division of Highways, Illinois Department of Public Works and Buildings.

The marking system adopted by the state of Illinois has been designed to serve a two-fold purpose:

First: To make the highways as safe as possible under present day traffic conditions.

Second: To impart as complete directory information to the traveling public as may be feasible.

Warning and Danger Signs.—To accomplish the first purpose, wooden signs, 42 in. wide and 24 in. high, with black letters on a white background, are erected along the completed highways of the state road system. These signs, which are located 400 ft. each way from every point of potential danger, are carried on 4 in. x 4 in. creosoted wooden posts, set 15 ft. from the center of the pavement on the right hand side; the bottom edge of the sign being 4 ft. above the pavement.

On all side roads and cross roads connecting with the improved state roads, the signs read: "Danger—State Road." The word "danger" is painted red on a white background, the letters being 7 in. high and 4¾ in. wide. The words "state road" are painted black, the letters being 5 in. high and 2½ in. wide. (See Fig. 1.)

On the paved roads the signs read: "Look"; "Caution"; or "Danger"; depending upon the location.

"Look" signs are erected where the driver need not slacken speed but should be on his guard.

"Caution" signs are erected where some slacking of speed and a certain degree of care are necessary.

"Danger" signs are used only where there is imminent danger, i. e., where extra precaution must be taken and speed greatly reduced.

The letters in the words "look" and "caution" are 7 in. high and are painted black on a white background. The letters in the word "danger" are the same height as in the words "look" and "caution" but are painted red on a white background. Beneath these words, in letters 5 in. high and 2½ in. wide, the nature of the danger is indicated, i. e., "Sharp Curve R" (sharp curve right); "Cross Road"; "Side Road"; "S Curve L" (reverse curve left);; "School"; "Narrow Bridge"; etc. (See Fig. 2.)

Where continuous care for a certain distance is necessary because of the frequency of cross roads, curves, narrow bridges, schools, etc., "caution zones" have been established. Such zones are marked at each end with a board sign lettered "Caution Zone" (Fig. 3). These signs have a border of diagonal black and white stripes approximately 2 in. in width. Throughout the caution zone all poles, bridge rails, other stationary objects, and, where necessary, special posts near the feature of potential danger, are painted with diagonal black and white stripes; in this way a great number of confusing separate signs are avoided.

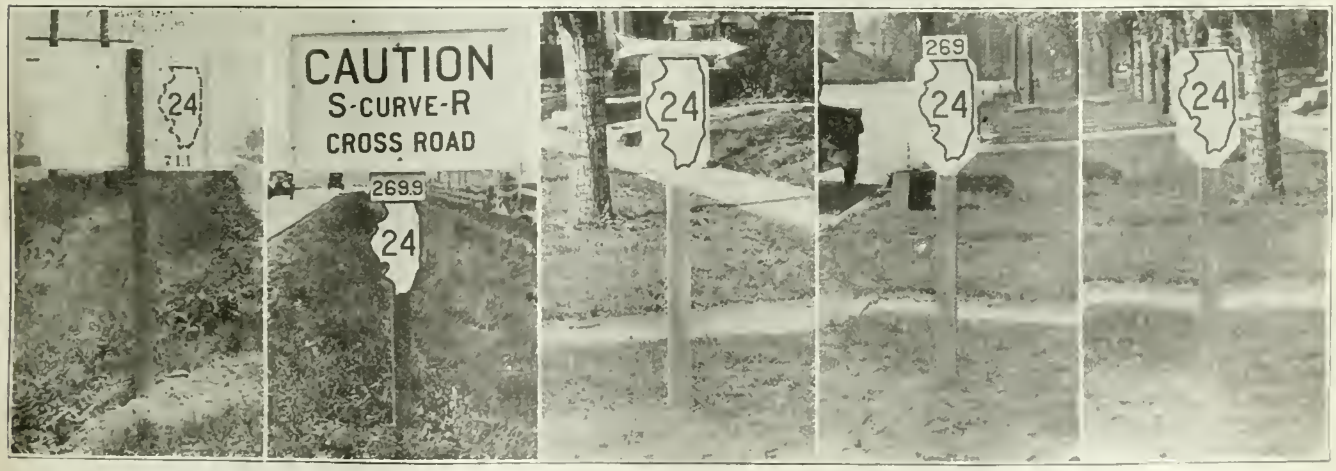


Fig. 5. Fig. 6. Fig. 7. Fig. 8. Fig. 9.
Markers for Furnishing Directory Information Used on Illinois Highway System.

System Carefully Studied Before Final Adoption.—Before the final adoption of this system of warning signs, a 60-mile stretch of road was signed in this manner and studied for a period of several months. This study resulted in a number of minor modifications. At first the signs were so erected that the line of sight of a driver when 200 ft. away was perpendicular to the plane of the sign board. It was found that the painted surface being glossy caused a reflection of the headlights at night so that the lettering could not be read, conveniently, until the driver had approached within 50 ft. of the sign. On the other hand, the very fact that this reflection occurred made the sign very conspicuous, at distances even as great as one-half mile, under favorable conditions. In order, however, that the legend might be more readily deciphered at greater distances, the sign boards are now set normal to the center line of the road. At this angle the signs are still very conspicuous at distances of 1,000 ft or more; and the lettering may be read at night at distances of from 50 to 100 ft.

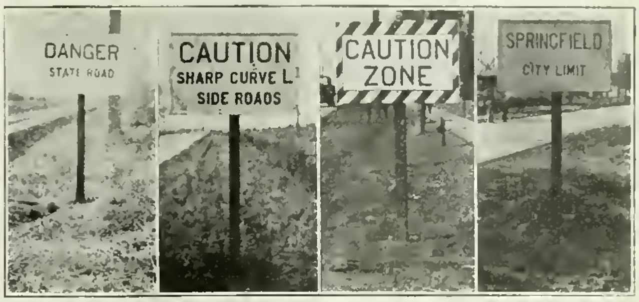


Fig. 1. Fig. 2. Fig. 3. Fig. 4.
Warning and Danger Signs Used in the Highway Marking System of the State of Illinois.

These signs are greatly appreciated by drivers, especially at night, inasmuch as they give ample warning of approach to curves and other features requiring more or less care on the part of the driver.

To Guide the Traveling Public.—To accomplish the second purpose—that of furnishing directory information to the traveling public—the following system has been adopted.

First: At the corporate limit of each city and village, a sign board of the same size as those carrying the warning signs is erected. The name of the city and the words "city limit" appear on that side of the sign faced by the traveler when approaching the city. (See Fig. 4.)

At the corporate limit there is erected, on the right hand side of the road as the traveler leaves the city, a sign on which is lettered the name of the next town and the distance thereto; also the name of the next principal objective point on the route and the distance thereto.

Second: All state routes are numbered. The back of each warning sign carries this number. On these signs the borders of the state are outlined in black; and within this outline the route number appears in black numerals 5⅜ in. high. Inasmuch as two warning signs are erected at each cross road and each side road on the state system of highways, the traveler is advised at frequent intervals of the number of the route on which he is traveling.

In addition to the route number, by means of red numerals, the distance along the route from its northerly or easterly terminus is noted on each rural warning sign in miles and tenths of miles. (See Fig. 5.)

At all cross roads and side roads leading to nearby cities and villages, an aluminum plate appears just below the sign board. On this aluminum plate the state borders are outlined, as before described, with the route number in raised black numerals and the mileage in raised red numerals. (See Fig. 6.)

The final scheme contemplates the showing on a complete road map of the state not only the route numbers but the mileage numbers of each important intersecting road, which is marked by an aluminum sign. This enables a traveler at any intersecting road to check his exact location by comparing both the route number and the mileage number of the intersection with those indicated on the map. The map, however, will not be available for some months.

Illustration of Use of This Marking System.—Assume that a traveler desires to start from Chicago, having Chillicothe in Peoria county as his objective. An examination of his map would show that he should follow Route 4 from Chicago to Joliet; Route 7 from Joliet to Depue; and Route 29 from Depue to Chillicothe. If he is a stranger, the city limit sign, as he enters Chillicothe, will advise him that he has reached his destination.

Again, assume a traveler desires to start from East St. Louis, having Delavan in Tazewell county as his objective. An examination of his map would show that Delavan lies about 4½ miles east of State Route 24; and, further, that the red mile number of the cross road leading to Delavan is 25.9. Without reference to the map thereafter, the traveler could hold in mind that he should follow Route 4 from East St. Louis to Springfield; Route 24 from Springfield to the cross road on which the mileage number (25.9) appears; then turn east and drive approximately 4½ miles to Delavan.

This system will enable a traveler, with very little field use of the map, to reach any point in Illinois by noting on a card or memorizing the route numbers and the mileage number of the intersection where he may turn off the main route.

Marking Through Cities.—No warning or danger signs appear within the corporate limits of cities and villages; therefore aluminum markers, showing the route number and the mileage (even miles only) erected on independent posts are used at street intersections to direct traffic.

Three different patterns are in use for the city markers, all of which have in common a double-faced flat plate (approximately 22½ in. high by 11 in. wide) showing the state outline in black and the route number in raised black numerals. At turns, an arrow pointing in the proper direction appears above the standard plate. At even miles, the mileage number in raised red figures appears at the top of the plate. At other intersections the plate embodies no special features.

One or the other of these designs is erected at each paved intersection on the far side of the intersecting street. (See Figs. 7, 8, and 9.)

The erection of these markers on independent posts, always approximately at the same position relative to the street intersections, undoubtedly will prove more satisfactory as a guide through cities than where telephone poles or other objects are used, the location of which is not always favorable for the guidance of traffic.

The route numbering system has been followed in the state of Wisconsin for some years. Generally, the system which we have adopted in Illinois is somewhat similar to that in effect in Wisconsin; however, it is believed that the addition of the mileage number at cross roads, making it possible for a traveler who has a highway map to check his position at every cross road, and the erection of signs on independent posts through cities, are features of distinct advantage.

California State Highway Commission Has Spent Over $52,000,000. The total expenditures of the State Highway Commission of California up to April 1, 1922, totaled $52,646,000. This sum does not include motor vehicle funds, which are used almost exclusively for maintenance. The estimated unobligated balance available from all sources, exclusive of motor vehicle funds, is $33,700,000. At the present rate of construction it is expected these funds will be largely obligated during 1922 and 1923.

Investigation of Sulphide Cement

By H. F. CLEMMER,

Engineer of Tests, Illinois Division of Highways.

The construction of the large number of miles of concrete roads in Illinois during the past few years has necessitated the inspection and testing of millions of barrels of cement of varying quality. This work has been accomplished by the Bureau of Tests of the Highway Division through its engineers stationed at the mills furnishing the product to the State. Though the 24 hour test is indicative of the quality of cement later tests sometimes show the material to be of inferior quality. When this proves true the cement is immediately rejected and an investigation conducted to determine the cause of the weakness in the product. One of the most important investigations of cement of this nature was one which was conducted in the fall of 1921 on sulphide cement, known by this name because of its large content of calcium sulphide.

This material was of a peculiar dark greenish hue which would bleach out when exposed to the air indicating without question that oxidation was taking place. As practically all tests were conducted on cement specimens stored in water the oxidation process could not take place until after the specimens were broken, thus a sufficient strength was secured to pass state specifications.

When it was noticed that this cement changed color while being exposed to the air samples were secured and the material was investigated at the Laboratory. A chemical analysis disclosed the presence of 2 per cent of free sulphur which when reduced resulted in .51% of calcium sulphide. The disclosure of the sulphide proved that oxidation of the cement could not help but take place when the material was exposed to the air. The effect of this oxidation on the strength of the cement was clearly indicated when briquettes made of this material and exposed to the air were tested, the results showing a decrease in strength with age.

At the appearance of this cement an engineer from the Bureau of Tests was sent to the plant producing the material to determine, if possible, the reason for the large amount of sulphur in the cement. It was found that the presence of sulphides was due to the method employed in burning the limestone and clay in the kilns. In this particular case the coal dust was not properly oxidized in the kilns, the result being that a goodly portion of the coal dust remained in the clinkers. This condition was caused by the use of an oversized blast nozzle and the application of an insufficient pressure. Acting upon the suggestions of the engineer of this Bureau the plant management cut down the size of the blast nozzle from 18 in. to 10 in. and also increased the pressure. This change resulted in a more complete ignition of the coal dust and eliminated the sulphides which had been the cause of the rejection of the cement. No further trouble has been experienced with this mill as their product is now standardized and can be used without danger in road construction.

In the investigation conducted by this department briquettes were made of normal cement and of sulphide cement, both being accorded the same treatment, as it was desired to obtain a comparison in strength of the questionable material with that of a standard cement. Some of each of the sets were stored in water while others were stored in air, as it was thought that a difference in storage would have an effect on the results. Enough briquettes were made to allow tests at the end of 7 and 28 days, 3 months, 6 months and 1 year. Thus far all of the specimens with the exception of those reserved for the year tests, have been broken.

The tests show that in practically every case the normal cement specimens tested at higher strength than the specimens which were made up of sulphide cement, the storage being the same in both cases. The following table gives an average of the results obtained in the tests to date. It is to be noted that the sulphide specimens stored in the air decreased in strength with age while the others appear to increase in strength with age, although a slight falling off is noticed at the end of six months.

	Neat cement				1:3 mortar cement.	
	Sulphide cement.		Normal cement.		Sulphide cement.	Normal cement.
Storage.	Air.	Water.	Air.	Water.	Water.	Water.
7 days..........	455	485	448	660	167	280
28 days..........	500	537	448	610	283	378
3 months.......	438	592	492	700	383	433
6 months.......	338	590	435	613	365	397

Highway Construction and Maintenance on Economic Foundation

Address at Annual Meeting of Chamber of Commerce of the United States

By THOMAS H. MACDONALD.
Chief U. S Bureau of Public Roads.

All the aspects of highway improvement are so modified by the particular conditions of the locality, small or large, that many dogmatic assertions, predicated upon insufficient or circumscribed data, which we have accepted as almost axiomatic, fall down when examined in the light of real fact.

The Short Term Bond Issue and "Permanent Roads" Fallacies.—For example, it has been accepted as a tenet that highway bonds shall be issued for a shorter period than the life of the road. The Cumberland Pike, the first and only great national highway of the early days, was opened to traffic about 1818. Today, after a full century, that highway is still in existence, rehabilitated and carrying an ever-increasing traffic. It is true that, due to changes in overland transportation, there was a long period when the highway fell into disuse and disrepair, but today, with the surfacing repaired and rebuilt, the same road-bed and most of the same waterway structures are serving traffic.

The extension of this road from Baltimore to Cumberland, originally a state project, was resurfaced in recent years at a nominal cost. This light surfacing was placed for horse-drawn traffic, but with continued maintenance and necessary reconstruction from time to time, is now carrying heavy automotive traffic. Under the theory just mentioned, for how long a period would the bonds, had the road been so built, have been proper? Apparently the road is in better condition today than it has ever been in the past.

The term "permanent roads" is a fallacy which is responsible for more or less of the unsound theory which has been advanced with reference to bond issues. There are certain of the essentials of road construction, such as the road-bed and drainage structures, that can be so built that the deterioration is so slow that they may be properly termed "permanent." Road surfaces of whatever type deteriorate. Maintenance should begin as soon as the surface is thrown open to traffic, and the higher the cost of the road, the more careful in detail should be the maintenance.

Traffic Regulation An Administrative Matter.—There is also the fallacy of the imposition of detailed and arbitrary legal limitations upon the character and weight of the loads which shall use the roads. Proper regulation, within certain reasonable legal limits, of the use of the roads is an administrative matter. Even in a single state conditions vary to the extent that loadings which may be carried without deterioration of some road surfaces will inflict untold damage upon others. Yet under the average regulatory law the utility of the best roadways is not realized in full, nor is the safety of the lesser capacity roadways assured.

Research in the field of the weight of loads that can be carried by different road surfaces is revealing definite information. The influence of subgrade soils, tire equipment, distribution of the loads to the wheels, the speed and many other variables is too complex to be written into law. The seasonal variation alone in the carrying capacity of the roadbeds, due to moisture conditions, is one of the most serious of all causes of road damage, and for this single reason the highway authorities must be given wide discretion in traffic regulation. There are many other fallacies which must be cleared away before we can hope to reach sound conclusions as to far-reaching permanent highway policies which will justify themselves over a long term of years.

Major Services Rendered by the Highway.—There can be no question as to the service that highways render (1) to the owner of the motor vehicle privately operated; (2) to the operator of motor-truck lines and motor-bus lines, the granting of franchises being followed by a real financial return; (3) to real property in the rural districts; (4) to the property within the urban limits, or, if more acceptable, to the people as a whole within the cities. All foodstuffs originate upon a highway, some place, and the nearer to the district that the perishable foodstuffs, such as garden truck, milk, eggs and butter, can be produced, and the more directly and quickly they can be transported from their point of origin to these people, the cheaper will be the cost and the better will be the quality.

Under these four classes may be grouped the major services which are rendered by the highway, but these do not bear a constant relation to each other, nor does the highway maintain a constant relation to each of these. The truck gardener is more dependent upon improved highways than is the farmer who raises only annual crops.

Thus the relative share of the cost of highways may not remain constant, but is is difficult to harmonize with the tenets of fairness and equity any plan of financing which does not distribute some part of the cost to each of these four services.

Major Highway Development Will Be Upon 7 Per Cent System.—A proper financial policy cannot be established unless there is functioning an efficient, stable highway administration. This applies regardless of the unit that is under consideration. With the exception of a very few states it is apparent that the major highway development for the next decade and probably longer will be upon the so-called 7-per cent system which is now being established under the requirements of the Federal Highway Act of November, 1921.

We have now on a national scale the inauguration of the first cardinal principle of efficient highway administration—the classification of the roads into selected systems. On the 7-per cent system federal and state funds will be concentrated until completion.

This classification, recognizing with full credit the progress made by many of the states before the federal enactment, is fundamental. Through its operation the roads of greatest importance are fast improved and all the work done is accumulative toward the completion of a system of interconnected and correlated traffic lines as between the communities within the states and between the states themselves. As the highway systems are completed the traffic will become more and more organized and concentrated on the improved roadways. If these systems are not properly selected they will eventually have to be revised and so much of the investment jeopardized.

In sequence of importance is the proper improvement of the highways so selected. Up to a certain point the steps in the improvement of all types of roadways are the same. The selection of the best location, the building of the roadbed by excavation, filling and draining, the building of the necessary culverts and bridges, the building of guard rails, approaches and all the incidental construction will be as carefully and thoroughly done under an efficient highway administration for all types of highways.

Selection of Type of Surface All Important Item.—The selection of the type of roadway surface is the all-important item from the standpoint of the highway service and highway finance policies. The service to be rendered must determine the selection of the type of highway. Here again research and investigational studies are rapidly fixing within reasonably definite limits the kind and volume of traffic which can be carried by the different roadway surfaces within reasonable maintenance costs.

Such a selection will determine the proper financial policy, for it will provide the basis for the establishment of an annual highway expenditure budget. The major items of the budget will include (a) maintenance, (b) reconstruction, (c) new construction. Reconstruction is included separately from maintenance for in the progress of highway improvement the replacement of old surfaces is usually by a higher-type surface and consequently the road is improved beyond its first condition.

The amounts needed for maintenance and reconstruction will be determined from the records and reports of the condition of roads in the system. The new construction requirements in the majority of the states are capable of absorbing all the funds that can be made available, so it is in the fixing of this fund that the most care should be exercised. It should be sufficient, however, to complete the first construction of the state system within the shortest period consistent with good management and the maintenance of competitive prices.

It is believed that a proper financial policy will require first that all of the maintenance funds be met from the revenues derived from the road user; second, that the costs of reconstruction be met from the revenues derived from both the user and from states taxes, the relative percentages being different for states and for the different types of roadways built, third, after deducting the federal aid, the cost of new construction should be divided between the road users and other state taxes from both urban and road surfaces.

Division of Revenue for Reconstruction and New Construction. Just how the respective revenues for reconstruction and new construction shall be divided between revenues from the road users and other classes of revenues, and how these costs, once apportioned, shall be divided to the several classes of road users and the different classes contributing to the other revenues, must be determined upon the most thorough research and investigation.

It has been stated that the total expenditures for rural highway purposes in the United States for the past year were approximately $600,000,000. These revenues came from the following sources.

	Per cent.
Local Road Bonds	33
Federal Aid	14
State Road Bonds	7
State taxes and appropriations	12
County, township and district taxes and assessments	14
Motor vehicle revenues	19
Miscellaneous	1

Federal aid and motor vehicle revenues constituted 33 per cent, the remaining 67 per cent either directly or will eventually be paid from the state and local taxes. It is believed that a very considerable readjustment of these sources of revenues must be made, so that a larger percentage will be paid by the road user and a lesser percentage from state or local taxes. This statement of motor vehicle revenues is not fairly representative of the total funds collected directly or indirectly from the motor vehicles, for our estimates show the following revenues paid during the fiscal year 1921:

Federal taxes paid by manufacturers on passenger cars and motor trucks	$115,546,249
State registration fees	122,178,654
Personal property taxes	52,500,000
Wheel and privilege license	3,636,243
Gasoline tax, 17 states, calendar year 1922, estimated	11,000,000
Total	$305,161,146

The total of $305,161,146 is equivalent approximately to $30 for each car and truck registered during 1921. This total sum, it will be noted, amounts to over one-half of the total estimated road expenditure for 1921.

Consider also the question of gasoline consumption. It is probable that the total gas consumption for use in operating automotive vehicles is not far short of 4,000,000,000 gal. per year. An advance of 1 cent in the price of gasoline on the annual consumption would amount to approximately $40,000,000.

40% of Cost of Federal Aid Roads for Permanent Features. Facts as to the type of construction which is going into the road building program must also be given consideration. For over 11,000 miles of federal-aid roads involving a total cost of over $188,000,000, the surfacing cost is 60 per cent and the remaining 40 per cent is made up of: Grading, 22 per cent; structures, 14 per cent; shoulders, 1 per cent; engineering, 3 per cent. That is, 40 per cent of the expenditures were for the permanent features of the road.

The greater part of the expenditures for surfacing can be rightfully considered in the same class, for it is being successfully demonstrated that by supplementary construction, such as the placing of new surfaces and widening by addition of shoulders, the greater part of the investment can be continually maintained and thus preserved indefinitely. Expenditures of this class fall into the category of maintenance and reconstruction, and if continuance of these two can be relied upon the original investment is preserved indefinitely. Therefore, little fault can be found with the soundness of the financing if bonds are issued for new construction provided that the original investment is thus continually preserved.

Of all these requirements it appears that the funds for the new construction in the amounts that will be needed will be the most difficult to secure. The public should not be called upon to bear this entire cost as au annual expense. Rather is it fair to distribute these costs over a period of years extending beyond the time of the maximum expenditures for new construction. It is not doubtful that succeeding generations will enjoy the use of the highways which are being built now, and there is nothing unfair in pursuing a financial policy which distributes a portion of the cost beyond the immediate period. No enterprise requiring funds in the large amounts that they will be required for the new construction or highways can go forward without anticipation of revenues.

Six Definite Principles for Road Bond Issues.—Experience in the administration of highway work has already established certain definite principles without the observance of which it would be highly unsafe to resort to bond issues. The major principles may be outlined as follows:

1. As a general proposition state, not local, bonds should be issued for the building of the state highway system. In any case the total amount of bonds to be issued for any one year or over a period of years in any state should be subject to the control of one central body.

2. Sufficient revenues must be derived from the users of the highways to pay all of the maintenance and a percentage of any reconstruction charges.

3. All bond-built highways ought to be maintained under the direct supervision of the state highway department, which also must have jurisdiction of the revenues from the road users. The proper maintenance of all bond-built roads must be considered a first lien upon such revenues.

4. The proceeds of bonds must be devoted to a system of roads so devised that as the system is completed these roads will in fact continually serve the major traffic in the vicinity. This means that the only safe sequence of improvement is in the order that the different sections of the system serve the traffic.

5. Bonds should not be issued in an amount beyond the ability of the traffic of the present and immediate future to pay revenues sufficient for the proper maintenance of the roads built from the proceeds.

6. The type of roads built with bonds should be adjusted to the traffic which they will be called upon to bear within the reasonable future.

It will be noted that little has been said as to the uses which are to be made of the highways, but it must be remembered that the whole question of highway transportation is in its infant stages. Careful investigations and studies are now going forward to determine both the economic limitations of highway transport and of the necessarily adjusted highway construction. We have made rapid progress during the past two years toward such determination, and the suggestions which have been made are based upon an administration of a highway program predicated upon the results and determinations of these scientific researches and investigations.

If permanent policies can be adopted and carried forward without change over a period of years the necessary roads can be built without undue burdens upon the public. The result will depend upon foresight and adherence done by foreseeing now and adhering to safe and sound financial policies.

Lower Prices Reported for Various Highway Materials

A considerably lower level of prices for the various items entering into highway construction is reported by the Bureau of Public Roads of the United States Department of Agriculture. This conclusion is based on the following prices by successful bidders on federal-aid roads during April and are averaged for the whole of the United States. Some of the figures cover a large volume of work well distributed over the country, while others are based either on small volumes or scattering reports.

The figures which cover the cost in places are as follows: Earth excavation, common, 33 ct. a cubic yard; rock excavation, $1.26 a cubic yard; gravel, $1.44 a cubic yard; sand-clay, 45 ct. a cubic yard; crushed stone, $3.42 a cubic yard; structural concrete of various classes ranges from $14 to $21.20 a cubic yard. For surfacing the following are the prices by the square yard: Gravel, 40 ct.; surface-treated macadam, 50 ct.; bituminous macadam, $1.06; bituminous concrete, $1.97; plain cement concrete, $2.17; reinforced cement concrete, $2.54; and brick, $3.70. Reinforcing steel has cost $0.053 a pound and structural steel $0.059 a pound. Cement has been furnished to contractors by the following states at the prices given by the barrel: New York, $1.73; Wisconsin, $1.94; and Arkansas, $2.70.

Big Increase in Automobile Production in May.—Figures received by the U. S. Department of Commerce show a very large increase in May in the production of passenger automobiles and trucks. The total production of passenger cars in May, so far reported, amounted to 231,699, compared to 197,221 in April. This is an increase of nearly 18 per cent. The total truck production in May was 24,603 machines, compared with 22,227 in April.

Machine Built Tar Penetration Macadam Roads of St. Louis County, Missouri

By GEORGE H. MARTIN,
Consulting Engineer, General Tarvia Department, The Barrett Co.

St. Louis County, Missouri, with an area of 487 miles and a population of a little over 100,000, surrounds on three sides the city of St. Louis with an area of 61 square miles and population of nearly 800,000. The city of St. Louis has a county organization of its own, so that St. Louis County is confronted with the rather unusual condition of having to handle the major proportion of the traffic tributary to a large city without having any revenue from that city available for its road work. A number of the old roads in St. Louis County were originally built with waterbound macadam, and are in fairly good shape to serve as foundations, but are entirely too rough to carry present day traffic in a satisfactory condition.

Stone Spreader Distributing Wearing Course.

During the past two years, under the direction of Mr. Wm. Elbring, the county highway engineer, about 8 miles of these old waterbound macadam roads have been resurfaced with a tar macadam top. In carrying out this work several unusual methods of handling material have been devised and put into practical use.

It has been the idea of the engineer that the original road should be disturbed as little as possible. It has been sacrificed only where sections of the old road were too high to make a satisfactory grade. In general it has been the policy of St. Louis County to build up with new stone on top of the old foundation.

Special Device for Spreading Stone.—In work of this sort, the first course of stone ranging in size from 1 in. to 3 in. is spread upon the old road. For spreading this stone Henry J. Bangert and Lewis H. Bangert, who have charge of the work for the county, have devised a stone spreader, shown in one of the accompanying illustrations, which is attached behind a dump truck. The stone goes down into the hopper of the spreader over a series of bars spaced so that the dust and the fine stone fall down to the bottom of the road. The depth of stone spread behind the truck is regulated by raising the hopper above the bottom runner to the desired depth. The machine spreads the stone in a very even layer. It spreads to a width of 8 ft., and it is customary practice to spread the material down the center of the road first, and then shift it to the sides with a road grader, pulled either by a truck or the road roller.

In spreading the stone for the foundation course, it is customary practice to use three spreaders, two working side by side and the center one a few feet ahead. It is thus possible to spread the stone uniformly over a width of from 22 to 24 ft. at one time, and very little shifting of the stone is necessary.

After the foundation stone is placed it is rolled with an ordinary three-wheeled roller, and the spaces between the stone are filled with screenings. Water is used to assist in thoroughly consolidating this foundation course.

In cases where it is necessary to take off the high points of the old road, it is torn up with a scarifier attached to the grader. After being torn up it is leveled and rolled and the new foundation is put in in exactly the manner described above.

Spreading Stone for Top Course.—Upon this prepared foundation there is placed a 3 in. course of tar penetration macadam. The stone for this course has an average size of 2½ in., and is somewhat better selected stone than that used for the foundation course. The same spreader is used in placing this stone as was used for the foundation course. The fact that dust and very fine stone falls immediately to the bottom of the penetration course is particularly valuable for this type of construction. Very little replacing of the stone surface is necessary after it has been placed with the stone spreader. Such reshaping as is necessary is done with the road grader, since it has been found that better results are obtained in this way than by hand, and the cost is somewhat lower.

Applying the Tarvia and Gravel.—The penetration course is thoroughly rolled, and then given an application of from 1½ to 1¾ gal. of Tarvia X. This material is delivered hot in motor trucks from the plant in St. Louis. The actual amount of binder used varies somewhat with the condition of the stone.

Upon this course there is immediately distributed gravel ranging in size from ¼ in. to ¾ in. About ½ cu. ft. per square yard is used. This material is distributed on the job with an automatic distributor attached to the rear end of the truck. The distributor consists of a hopper and a revolving disc upon which vanes are attached. The disc is driven by a shaft from the differential of the truck. In using this apparatus the truck is run backward down the road, and in this way the gravel is distributed over the top of the tar so that the tar does not stick to the truck wheels. Afer distributing the gravel it is thoroughly rolled and also swept with a broom attached to the roller. The object of this is to thoroughly fill all the surface voids. Any excess material is swept off to the side of the road. Every precaution is taken to thoroughly fill this penetration course so that the seal coat will lay on the top as a blanket.

For the seal coat about ¾ gal. per square yard of Tarvia X is applied with a motor truck distributor. This is covered with just sufficient roofing gravel to keep the tar from picking up. The roofing gravel ranges in size up to about ½ in. This cover on the top course is also distributed with the same gravel spreader used for distributing the gravel on the top of the penetration course.

After the cover has been placed on the seal coat the entire road is thoroughly rolled, and is then thrown open to traffic.

Automatic Distributor Spreading Gravel.

Since a comparatively small amount of cover is used on the seal coat, it is sometimes necessary to go over the road again and put on additional cover where needed.

It is always planned to give these roads a second seal coat of about ½ gal. per square yard of Tarvia B applied with motor truck distributor during the same season that the road is built. This second seal is also covered with roofing gravel.

Organization and Costs.—Under the direction of the Bangert Bros. this work has been carried on with only 5 men on the job, as follows:

1 roller operator.
1 roller helper.
2 laborers.
1 superintendent.

The Bangert Brothers act as superintendents on the jobs, and they have devised the spreading machinery used. The gravel distributor has been patented, and an application for patent has been made for the stone distributor.

Because of the low labor cost it was possible to build the Florissant Road, 22 ft. wide and 3 miles long, in 1920, for about $16,000 per mile. This road had a stone base which averaged 6 in. in depth. The costs given are based upon a cost of stone of $2.30 per cubic yard on the road, gravel at $2.85 per cubic yard on the road, and Tarvia at 15 cts. per gallon delivered. These costs were in 1920.

On one mile of the Telegraph Road built in 1921 a penetration base was substituted for the waterbound base described above. The method of constructing the penetration base was substantially the same as that of constructing the penetration top up to the application of the seal coat. No seal coat was applied on the penetration base. This road, which was 18 ft. wide, cost about $16,500 per mile in 1921.

By working in the manner described, it has been possible to utilize the old macadam roads as a foundation, and cover them with a smooth, even pavement. A large amount of money has been saved for the people of St. Louis County by this plan. The results obtained are most excellent and this is largely due to the efficient manner in which the work has been planned and carried on.

All of this work was under the personal direction of Mr. William Elbring, County Highway Engineer, and the Bangert Brothers acted as superintendents for the county on the work under Mr. Elbring.

Heavy Loads on Massachusetts Roads

An investigation made during tho summer of 1920 and 1921 by the Massachusetts Highway Department showed that 18 to 20 ton loads were being carried over the highways. The investigations were conducted by A. P. Porter, Inspector of the Division of Highways, Massachusetts Department of Public Works. In a paper presented recently before the Boston Society of Civil Engineers gives some interesting information on his work. We quote as follows:

Purpose of the Investigation.—When we started the investigation there were three facts we wanted to determine:

1. The Maximum Load.—Actual weight of heaviest truck load and how its weight is distributed on the wheels. This is to be used as a basis of computing the greatest stresses in the pavement and in bridges.

2. Overloaded Trucks.—The ratio of the actual load to the manufacturers' rated carrying capacity is called the "load factor." While we found some trucks carrying as much as two and three times the rated capacity, the average load factor for all the trucks carrying any load is about 1, and taking into account the trucks returning empty the average load factor is about 0.5.

3. Intensity of Traffic.—A highway engineer is often called upon to compare the traffic over one road with that over another. For this purpose it is necessary to stop every heavy truck passing a certain point, ask the driver a number of questions regarding the weight of his truck and load, and find the total weight of all the trucks in a given period of time. I adopted "tons-per-hour" as being probably the most convenient unit to express the volume of traffic. For instance, if one road carries ten times as many tons per hour as another, it is reasonable to suppose that the former road will wear out about ten times as fast as the latter and cost ten times as much to keep up, other things being equal.

How Truck Weights Were Determined.—We started to weigh the trucks with two loadometers. The loadometer is a device on the screwjack principle, with an oil gage attached to give the weight. The two instruments are first placed under the rear axle, screwed up until the wheels are off the ground and the readings taken. Then this process is repeated with the front axle. The sum of the four readings gives the total weight of truck and load.

In using the loadometers, I found it is wise to choose a spot where the roadway is nearly level in both directions, for if one of the jacks stands on the sloping shoulder of the road, the side thrust will cause the screw to bind, and not only work very hard but may affect the readings.

During 1920, 90 trucks were weighed by the loadometers, and in 1921 100 trucks by the loadometer and 400 on platform scales.

The first two jacks which I used were calibrated to 20,000 lb. each, but the second pair, supposed to be an improved model, have a capacity of only 15,000 lb. each.

Some Heavy Loads.—The first truck I met after I began using these improved jacks was too heavy to be weighed with them and I had to resort to a neighboring 20-ton platform scale. The rear axle of this truck weighed 32,000 lb., the heaviest axle load I ever weighed.

The largest gross weight of a four-wheeled truck and load which we actually weighed was 38,300 lb., and the largest load on six wheels was 40,000 lb.

The proportion of the truck weight which comes on the rear axle of a truck varies from 70 to 87 per cent. It is not constant for a certain truck. As more load is added, the percentage on the rear increases.

It varies also with different makes of truck, different classes of commodities, length of wheel base, length of body, overhang, and how the load is placed. Loads of wool or cotton are sometimes piled forward over the cab. The average per cent. on the rear, for all makes, is about 78.

The legal limit in Massachusetts for the weight of truck and load is 14 tons, and outside the Metropolitan Parks and Sewerage districts there is also a limit of 800 lb. per inch width of tire. Since the largest tire practicable is 14 ins. wide or its equivalent, two 7-in. tires, this practically limits the legal axle load to 22,400 lb. even with the largest tires.

When the weight of the truck and load was over the legal limit several hundred pounds or more, we summoned the driver to court. So far this year we had 116 cases in court and secured a verdict of guilty in 109 cases.

Sometimes we made the truckman remove part of his load. On one occasion in Reading I stopped a truck going from Boston to Lowell which weighed 38,300 lb., and another owned by the same company going to Lawrence which weighed 34,100 lb. When told they could not proceed, they telephoned to Boston for another truck, which came out and took 25 bbls. of sugar off of one truck and 17 off of the other, which made this third truck overweight.

We divided the commodities carried into five groups:

1. Crushed stone, gravel, etc.
2. Oil, gasoline and tarvia in tank bodies.
3. Groceries, meat and drinks.
4. Wool, cotton and dry goods.
5. Machinery, lumber and furniture.

Our analysis of these figures shows some interesting conclusions; among others, that the loads going out from the city are very much greater than the loads going in toward the center. About 75 per cent. of the net load on any one of the through routes is going out from Boston, and noly 25 per cent. coming in. If these could be more nearly balanced the efficiency of this kind of transportation would be very much increased.

Mountain Road Work Shown in New Film

The most difficult road building in the United States—the construction of good highways through the National Forests of the West—is shown in a new United States Department of Agriculture motion picture, "Highroads and Skyroads." The picture, one reel in length, was made in the western tier of states under the supervision of highway engineers of the U. S. Bureau of Public Roads.

"The old frontier has gone, never to return," says the film at its opening, just preceding a scene showing the grave of Buffalo Bill on Lookout Mountain overlooking Denver. A contrast is drawn between the old prairie schooners and pack trains, of days gone by, and the motor cars of to-day. Surveying on high mountains and in narrow canyons, blasting, grading, and surfacing are pictured, and at the end some of the finished highways leading over the Continental Divide are thrown on the screen.

The picture is the first of a series dealing with the road building work in National Forests. It may be borrowed from the Department of Agriculture, or prints may be purchased at the manufacturing cost by authorized institutions.

Treatment of Sand-Clay and Top-Soil Roads with Calcium Chloride.—Experiments with calcium chloride for dust laying and maintenance of sand-clay and top-soil roads are being conducted by the Division of Tests and Investigation of the North Carolina Highway Department, under the direction of E. R. Olbrich, construction engineer.

Stabilization of Road Subgrades

Subdrainage by Deep Side Ditches and Tile Drains Compared in Paper Presented Feb. 15, at Conference on Highway Engineering at University of Michigan

By CHARLES M. UPHAM,
State Highway Engineer of North Carolina.

The extent of the effect of moisture on any subgrade depends upon the kind of soil in the subgrade, so that it is readily seen that the selection of soils which go to make up the subgrade is one of the most important factors in road construction. This detail is many times overlooked. In clay soils it has often been found that the soil nearer the surface of the ground is more satisfactory for subgrade construction. This undoubtedly is due to the fact that the soil has been broken up due to the action of frost, and that the finer material and colloidal matter has been washed out by the rains.

In the South there is what is known as top soil, which is a sand-clay composed of broken down rock, from which the finer colloidal matter has been washed. With the varying effects of moisture on the different materials it can be seen that the selection of soil for a subgrade is very important, and it is absolutely necessary to get a material of low capillary attraction and resulting high bearing value in the top of the subgrade. Many times the mistake has been made of taking all material from cuts and throwing it indiscriminately in the fills, whereas it would be to the great advantage of the road to select the material generally from the top of the cut and place this material on the top of the fill. In that way we would have the better material in the top of the subgrade and this would afford a higher bearing power for the construction of a road surface, which would have the same effect as increasing the depth of the slab.

There may be many methods of stabilizing subgrades. We cannot imagine any road so muddy and unserviceable that we could not build up a subgrade by putting sufficient number of rocks or crushed stone in the subgrade. We could also go to the other extreme of imagining a subgrade constructed of solid concrete, and there are other impractical methods of stabilizing subgrades, but on account of large mileage of roads which must be built, and on account of the comparatively small amount of money available for road construction, it is absolutely necessary that the most economic means possible be used in stabilizing the subgrade.

Drainage One of the First Principles in Road Construction.—It has been found and accepted by road builders that the most economic method of stabilizing the subgrade is simply to take away the water from the road foundation, or, better still, keep the water from getting into the subgrade. Therefore, one of the first principles in road construction is to so construct a drainage or sub-drainage system as to pipe away all springs or water from any source whatever, so that at no time would it be possible for any of this water to enter the subgrade and thus reduce the bearing power of the subgrade.

This can generally be done by constructing ditches parallel with the roadway, the bottom of which are from 10 to 18 in. below the subgrade or foundation of the roadway. When a road is hard surfaced it prevents any water from above entering the subgrade, as least until it has run to the edge of the pavement. The lateral side ditches intercept any water from horizontal capillarity or side seepage.

Water from Capillary Action.—There only remains, then the water which rises up through the ground by capillary action. This is the most difficult and expensive water to take care of, and it can readily be seen that on account of the capillary action varying in different soils the selection of subgrade material is very important. It can safely be said that the amount of water drawn up into the subgrade depends upon the supply and the class of material in the subgrade. Generally speaking, the coarser the material the less the capillary action, and also the reverse is true to the extent that the finer the material generally the greater the capillary action, although within certain limits the capillary action in the coarser material is quicker than in the finer material, but the ultimate amount of water raised, and the height it is raised, is not so much in the coarse material as in the fine material. And inasmuch as it is the amount of water present in the subgrade which influences the stability of the subgrade, it can be seen that in selecting material for the road foundation the coarser material should be selected.

Where Capillary Water in Subgrade Is Greatest.—From experiments performed by the Bureau of Public Roads it has been determined that the capillary water in a subgrade is greatest directly underneath the hard surface slab, which means that the part of the subgrade which should be the most stable is in reality greatly reduced in bearing power. However, the problem is to substitute for this portion of the subgrade a material which is less affected by the amount of water, or which has lower capillary action, which also means that the water does not rise so high in this particular selected material, and this is another way of saying that the subgrade is more completely stabilized by this selected material, because the amount of water in the subgrade directly underneath the slab has been excluded by the selected material.

Various cross sections of roadways have been designed for the purpose of doing away with these various conditions, and, of course, one of the universal solutions of cross sections is the side ditch, which intercepts any water from the sides, which would otherwise get into the subgrade.

Comparison of the Side Ditch and Tile Underdrain.—This generally consists of a ditch at the bottom of which is a pipe laid with loose joints and then the ditch filled in with crushed stone.

It has been thought by many that since this was called a drain it effectively drained all the water from the subgrade, but, undoubtedly, in many soils this drain did little or no good other than to intercept any free water which might otherwise find its way to the subgrade. In other words, it is quite likely that this drain was only effective in taking away free water which came from the surface or seeped through the ground horizontally.

It is quite doubtful if any drain ever carried away any appreciable amount of water which rose by capillary action. Therefore it can be seen that neither the open ditch nor the tile underdrain is sufficient to cope with the capillary water in any subgrade. We must, therefore, design against capillary water in addition to the longitudinal drains.

In the subject of tile underdrains there is a question as to their location. While the longitudinal underdrain will serve the purpose of intercepting water which would otherwise find its way to the subgrade, quite often transverse drains are necessary for the purpose of taking away water from springs or stratas which carry water underneath the road. The number and location of these drains absolutely depends upon conditions, and the amount of water which finds its way underneath the roadway. To carry the question of transverse drains a little further, and to more completely develop the idea, selected material which can be easily drained is sometimes placed underneath the road surface in thicknesses varying above 2 in. This material should be connected up by drainable material to the nearest drain or ditch. This is another very effective means of reducing the amount of water underneath the road slab which is a means of increasing the bearing value of the subgrade or road foundation.

The location of a lateral or longitudinal drain has been the subject of considerable discussion. One suggestion is to place the drain directly underneath the ditch, but this seems to be the improper place on account of water flowing in the ditch carrying the finer silt particles into the drain, which gradually make it less effective. It is undoubtedly better to construct the drain higher up on the shoulder and a little nearer the roadway surface.

Chemical Treatment of Subgrades.—There are many methods now being devised for the treatment of subgrades in order to overcome the water of capillarity, and to insure more complete stabilization, various chemicals are being used to experiment in the treatment of subgrades. Water-gas tar is a substance which has been used in subgrade experimentation. Other experiments show that Portland cement has an advantage in stabilizing subgrades. Experiments with low capillary material suggests that cinders, sand, gravel or crushed stone will bring about a stabilized subgrade only in a different manner. In all cases, the treated or selected subgrade material should be connected with the tile drains or ditches or drainage system, by means of the most drainable material and the subgrade, even if built of selected material, must be so constructed as to drain as completely as possible.

Comparison of Open Ditch and Tile Drain.—Neither of these is a cure-all. In some instances they help materially, but in other cases their effect is slight. There is a particular experiment which has been watched for several years. It is a surface treated macadam road. This particular road broke up every spring as the frosts came out of the ground. A complete investigation was made and what remained of the macadam surface was cleared away and, although it was expected to find a spring underneath the roadway, the only thing which was found was a layer of clay slightly over an inch in thickness. This layer of clay was slightly tilted to such an extent that water would percolate through the ground until it reached this layer of clay, and then on account of the impervious clay layer it would follow along on top of the clay and appear underneath the road surface. This amount of water on top of the strata of clay so weakened the road surface and subgrade that it broke up each year. It was noticed that this strata of clay was underlaid with a very coarse and easily drained sand, and the water which had collected on the clay strata was easily drained down through the holes cut in the clay strata. This matter is being mentioned because in order to show that the flow of water in certain soils is very slight and that tile drains will have very little beneficial effect.

In many instances it has been found that the flow of water in different soils varies from 1 ft. a day up to 20 or 30 ft. a day in clay soils. There is some question relative to the depth of drains and ditches. It is very evident that a ditch will intercept water the same as a tile underdrain, and also the tile underdrain will have the same effect in intercepting water as an open ditch. It is assuming that both are maintained. It is quite evident that it is more difficult to maintain a ditch than an underdrain on account of the fact that in tile drains the pipe is always available for the free water, whereas if an open ditch becomes stopped up the free water is backed up and allows a bigger supply of water for capillary action in the subgrade. The deeper the ditch the more difficult it is to maintain, and one more important point is the fact that a deep ditch must be maintained by hand, which should eliminate this kind of a ditch for consideration only where the depth of the ditch is necessary for water drainage. In many instances a shallow ditch can be maintained by a road machine.

The value of a tile drain is sometimes completely lost under certain conditions of frost, and in many instances the effectiveness of a tile drain is practically of no value, although there may possibly be a very slight movement of water through frozen ground. This, however, is very slight. In this particular instance, no doubt, the open ditch would be more effective, especially in taking care of any surface water, which through certain weather conditions such as a thaw, might be present.

Probably the most critical time for any road is after the ground has been frozen for some 2 or 3 ft. Under these conditions the effect of the tile drain would be greatly reduced. If this freeze is followed by a thaw the surface of the road is first affected and this condition brings about an excess of water on the surface of the road and directly underneath the slab. On account of the frozen material underneath, the free water cannot pass down into the drain and thus, in this instance, the value of a tile underdrain is reduced to a minimum. A more effective solution in this case is a shallow gutter. By this is meant a gutter from 10 to 18 in. below the subgrade with the shoulders and slopes so constructed that surface water and any free water occasioned by a thaw can readily find its way to the gutters.

It is assumed that all underdrains and ditches are constructed to grade and will thus quickly carry away any free water. Another very important point is that any free water which might for any reason exist in the subgrade must have a method whereby it can pass off immediately to the drain or ditch. In the case of ditches the existing conditions must be thoroughly studied before the location and depth is determined. If you are constructing a road on a fill, of course, there is no water to intercept, but in a cut which is on light grades or on side hill work, an intercepting ditch is very effective. On the heavier grades it is not necessary to make the ditch as deep as on the lighter grades, for the grade of the roadway has the same effect as the deeper ditch. If the ditches drain readily, all indications seem to point that it is seldom necessary to construct any ditch deeper than 2½ ft. or 3 ft. below the grade of the road. It is sometimes necessary to do so to get a suitable grade to drain the system.

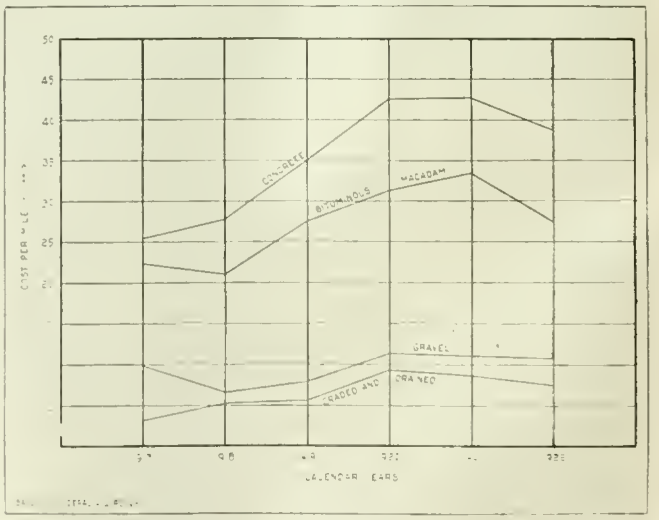
Tile Drain Has No Distinct Advantage Over Open Drain.—In summarizing, no distinct advantage can be claimed for the tile drain above the open ditch; nor can it be said that the open ditch is more favorable at all times than the tile drain. But there are certain conditions where a combination of the two will be the most practical. If an open ditch is used there is no advantage in making it any deeper than to intercept water, and should not be so deep that it cannot be maintained by machine; otherwise the maintenance will be a costly item. An open ditch can be used to intercept water as effectively as a tile drain. The open ditch must be constantly maintained and presents a hazard to traffic. On the other hand a tile drain will serve as well as an open ditch when used to intercept water from getting under the roadway. The maintenance of a tile drain is generally less than the open ditch, although many times its original cost of construction is greater. At no time does the tile drain present any hazard to traffic, and for this reason it should be given serious consideration.

Undoubtedly no decision can be made to the extent of stating that either the open ditch or the tile drain is preferable, but it can safely be said that there are conditions when it is more economic and desirable to use either one or the other. After a careful consideration of all the details it is quite likely that a combination of the open ditch and the tile underdrain is more suitable than either the one or the other.

In no case is it necessary to construct the open ditches or tile drains lower than that point which will intercept water, for, in practically no instance, do the drains reduce the amount of capillarity, and after all a combinaton which will most economically reduce the amount of moisture in the subgrade is the method to be selected, taking into consideration the first cost, cost of maintenance, and giving due consideration to any hazards which might be interposed on account of the open ditch.

Cost of Federal Aid Roads

The U. S. Bureau of Public Roads reports that on March 31 there had been completed since 1916, 11,017 miles of Federal-aid road and gives the mileage of each type and the average cost per mile. The figures are based on a large volume of work and are the most recent and reliable figures giving average costs for the whole of the United States. The figures cover the entire cost of construction excluding large bridges, and in a few cases the cost of engineering is not included:



Variation in Cost of 4 Types of Road Since 1917.

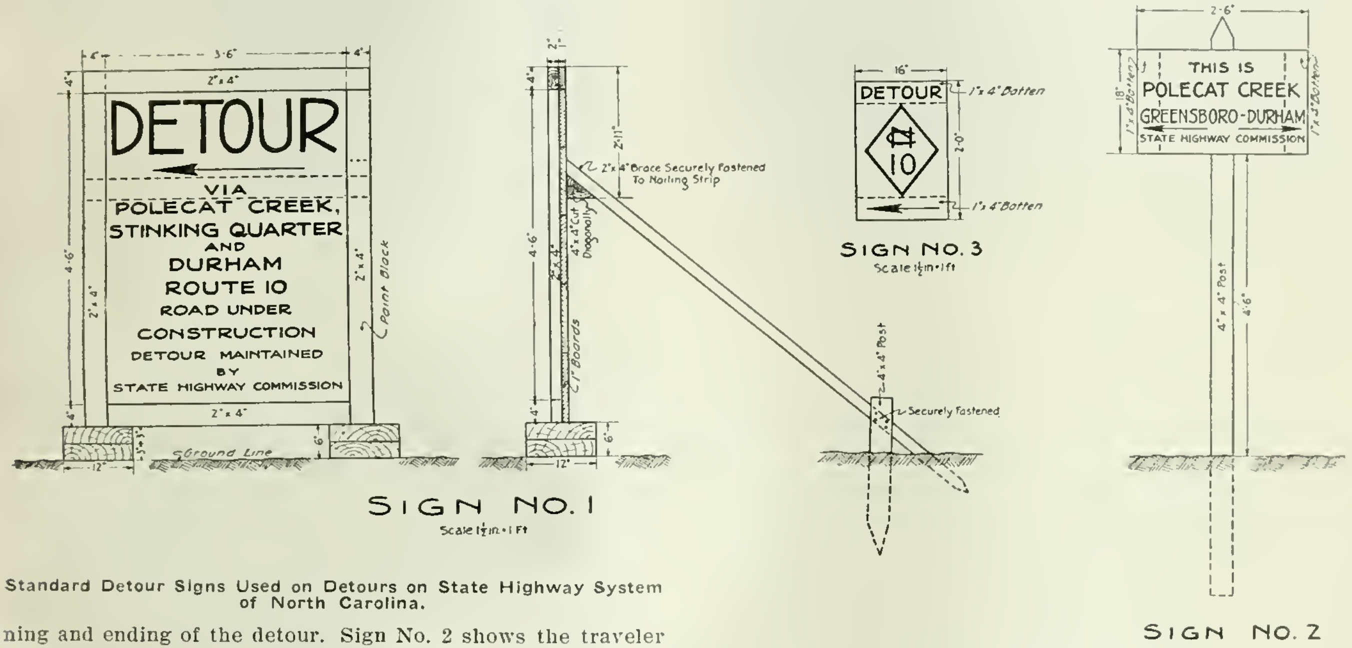
Type.	Cost per mile.	Miles constructed.
Graded and drained	$ 9,200	1,752
Sand-clay	6,850	1,338
Gravel	9,230	4,389
Water-bound macadam	14,000	294
Bituminous macadam	25,720	382
Bituminous concrete	43,500	511
Concrete	36,600	2,104
Brick	46,875	224

These figures are based on the entire period of operation of Federal aid but the major portion of the work has been done since 1918.

The accompanying chart shows the variation in cost per mile of four types of road since 1917. It is incorrect to assume that the rise in prices shown is due entirely to increased cost of labor and materials. During this period there was a general tendency to construct wider and more substantial roads to meet the needs of modern traffic.

Standard Detour Signs of North Carolina Highway Commission

The accompanying illustration shows the standard detour signs used on all detours on the state highway system of North Carolina. The signs are made from first class well seasoned smooth pine, free from knots. The backgrounds of the signs are painted a brilliant yellow, and the borders and lettering are painted black. Sign No. 1 is used at the beginning and ending of the detour. Sign No. 2 shows the traveler when a certain point has been reached. Sign No. 3 is placed at intervals along the detour to prevent any mistaking of the route.



Standard Detour Signs Used on Detours on State Highway System of North Carolina.

Surface Treating Macadam Roads in St. Lucie County, Florida

St. Lucie County, Florida, has, after considerable experience in surface treating many miles of highways, come to the conclusion that the method and materials outlined below furnish the most satisfactory results with the most reasonable expenditure.

Section of Surface Treated Dixie Highway.

The native rock of this region, which is used quite extensively in the construction of the county's roads, is comparatively soft and easily shattered by the impact of traffic. When treated, however, it makes a firm and serviceable road.

From results on his own highway system and observation of the results obtained in neighboring counties, the county engineer finally has adopted for this surface treatment a material having an asphalt content of approximately 85 per cent of 100 penetration. The asphalt is applied to the road in two treatments at an interval of from 30 to 60 days, each application consisting of ¼ of a gal. to the square yard. To secure maximum penetration the material is heated to a temperature of 250° F. In applying the asphalt, a 600 gal. Kinney pressure distributor has been used very effectively.

Immediately after the spreading of the hot asphalt, the road is lightly sanded, and traffic turned off for 24 hours. Then the road is again gone over and all spots which have bled, receive a coating of sand. When the road has been reopened for traffic for a time, it is examined once more and all bleeding or uncovered spots carefully sanded for the last time.

The use of local sand, dug along the road in most cases, adds to the economy of this construction in St. Lucie County, Fla., and a very good finish has been obtained with it. Texaco macadam binder is being used in the work.

Power Loss in Automobile Tires

The rubber laboratory of the U. S. Bureau of Standards is equipped with a special dynamometer for determining, among other things, the power loss in automobile tires. A great many of the standard makes of tires have been tested on this dynamometer, and valuable data are being obtained concerning the percentage of the power of an automobile engine which is absorbed by the tires under various conditions.

Some interesting figures have already been secured as a result of this work. For instance, an average 4-in. fabric tire, under conditions of normal load and air pressure, will absorb approximately 0.90 h.p. due to rolling resistance at a speed of 25 miles per hour. Under the same conditions, the power loss in a 4-in. cord tire is approximately 0.60 h.p., while a 5-in. cord tire represents a loss of 1.20 h p. The extent to which different parts of the tire contribute to the power loss has also been investigated. It is estimated that from 80 to 85 per cent of this loss is in the carcass, the tread contributes 10 to 15 per cent, and the tube probably less than 5 per cent.

Double Headed Trains for Hauling Batch Boxes in Steep Grades

One of the most difficult pieces of road construction ever performed by the use of locomotives and cars running on industrial track, without other assistance, was carried out last year by Winston & Co. on Route 18, Northumberland and Lycoming Counties, according to the June Bulletin of the Associated General Construction of Pennsylvania. A section of road approximately 3,400 ft. long, with two heavy curves in it and grades ranging from 7 to 8.02 per cent was constructed in this manner, through employment of double-headed trains, each train consisting of one 8-hp. and one 6½-hp. steam locomotive hauling ten 4 bag batch boxes, from bottom to top grade, until pavement became sufficiently hard to permit movement of transfer derrick (used in connection with combination truck and rail haul) to top of grade. The contractor had no expense due to accidents on this work.

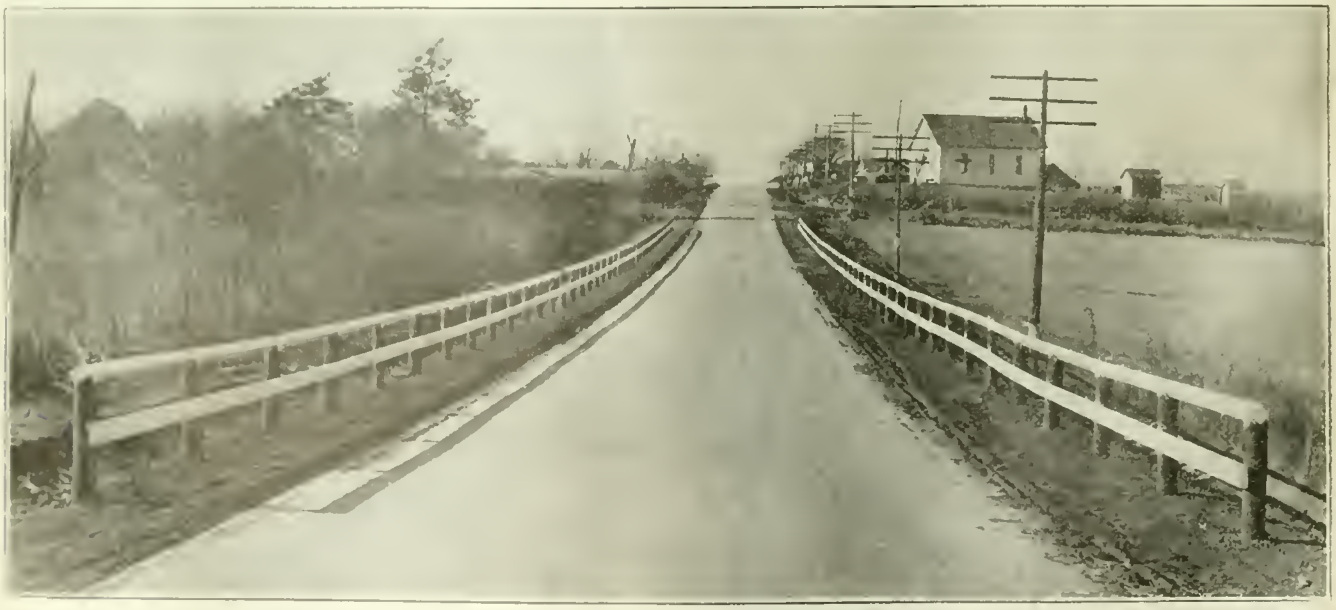
New 1-Yd. Dump Body for Avery Trucks

The accompanying illustration shows the new 1 yd. dump body equipment which the Avery Co., Peoria, Ill., is now furnishing on its 6-cylinder speed truck. This body can be dumped by the truck operator reaching through the small window in the back of the cab. The body is made of heavy gage steel

Avery Truck with New 1-Yd. Dump Body.

Ready Cut Guard Rails

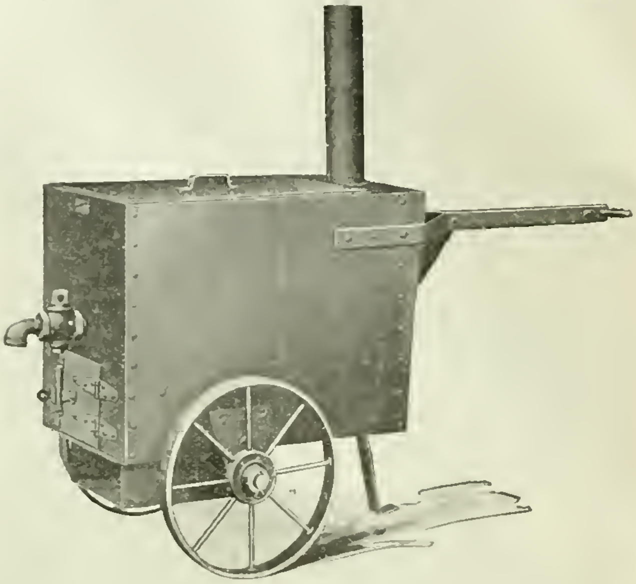
A guard rail that comes all ready to set up, and requires no skilled labor, nor extra tools for erection, has been placed on the market by the Long-Bell Lumber Co., Kansas City, Mo In these guard rails all mechanical details are made to comply with highway specifications. The posts are framed before being treated and are creosoted full length. The accompanying illustration shows the manner in which Long-Bell creosoted posts and yellow pine rails are used for guard rail construction along highways, on curves, fills, bridge approaches, culverts and other danger points. The posts are notched at the top before treatment. In that way there is no danger of deterioration of the post due to exposure of an untreated part to the weather, as might be the case if the posts were notched afterwards. All Long-Bell posts are treated by the pressure-vacuum process, and are stated to have a minimum life of 35 years. These posts are stocked by hundreds of lumber dealers throughout the country, and are obtainable through any retail lumber dealer.



An Installation of Long-Bell Guard Rail. The Black Creosoted Posts and White Rails Form Such a Contrast That the Guard Rails Are Easily Seen Either Against the Moonlight or on Dark, Stormy Nights.

Tar and Asphalt Heater for Road and Street Maintenance

A small tar and asphalt heater, especially adaptable to patrol work in road maintenance, has been placed on the market by Littleford Brothers, Cincinnati, O. The heater can be handled by one man. The capacity of the kettle is 25 gal. A convenient drain is provided at the rear where the valve is kept warm because of its close proximity to the fire box. The construction of this heater is exceptionally durable. The large fire box is fitted with renewable cast iron grates and the furnace shell is protected by liners of fire box steel. The rectangular kettle is removable. The seams are heavily welded, thus eliminating all possibilities of leaks and possible danger of fire. A removable cover is provided. The heater is mounted on two all steel wheels 18 in. in diameter with 2 in. by ⅜ in. flat tires. The axle is 1¼ in. in diameter. A handle, well braced and fitted with stiff leg is attached to front end at a convenient height for drawing the heater about. This heater is known as the Midget No. 69.

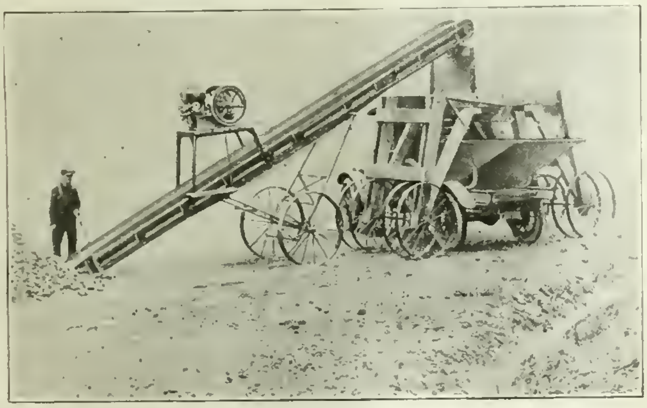


Midget No. 69 Tar and Asphalt Heater.

Experiences in Snow Melting.—In a discussion last fall at a meeting of the Materials Handling Division of the American Society of Mechanical Engineers, A. Parker Smith related some experiences in snow melting as a means for removing this material from city streets. On the basis of 14,000 b. t. u. per pound of soft coal or gas-house coke, and using the latent heat of fusion of 1 lb. of snow or ice or 140 b. t. u. he estimated that one ton of coke at $10.50 per ton delivered should melt 100 tons of snow. Estimating a 75 per cent heating efficiency, the fuel cost of a well-packed two-horse-truck load of snow would be 21 cts. On the same basis Mr. Parker Smith estimated the fuel cost of melting the snowfall on a 5th Ave. block in New York as $10.50. He also told of snow melters built 30 years ago, some of which were tried out in New York City. One of these set up in Hancock Square was used to melt 86,000 lbs. of snow in four hours, consuming 1,000 lbs. of coke. Difficulties of operation were found to be dirt in the water jacket and clinkers which clogged the draft.

Material Handling Unit for Concrete Road Construction

A flexible portable material handling unit for concrete road construction has been worked up by the Portable Machinery Co., Passaic, N. J. The unit consists of the company's contractor's type scoop conveyor, specially designed to handle abrasive material, a portable measuring hopper and an auto dump truck. In operating the unit the stone and sand are first placed in suitable piles along the roadway. One conveyor with a measuring hopper is assigned to the crushed stone and a duplicate outfit is assigned to the sand and cement. Both measuring hoppers are adjustable in size in order to provide for mixtures of different proportions. The man in charge of the stone handling outfit fills his hopper with the desired proportion of stone and the man in charge of the sand and cement handling outfit fills his hopper with the correct proportions of sand and cement. After the measuring hoppers are charged the dump truck operator drives under the stone hopper and receives the charge of stone after which he drives under the sand and cement hopper and draws these materials on top of the stone. The load is then driven to the concrete mixer and discharged into the mixer hopper and by the time the driver comes back to the measuring hoppers, they are filled and ready to discharge their next load. The conveyors and measuring hoppers are easily moved backward or kept in close contact with the piles of material scattered along the roadway. Both the conveyors and measuring hoppers are manufactured in various sizes by the Portable Machinery Co., Passaic, N. J.



Portable Conveyor, Measuring Hopper and Truck Taking Load.

17 States Now Tax Gasoline

Some of the results of a questionnaire sent out by Frank F. Rogers, State Highway Commissioner of Michigan, to 17 states having a tax on gasoline are summarized in the table below:

State.	Rate per gallon, ct.	Estimated receipts for year.	No. of cars registered.	Average per car.
Arizona	1	$ 166,021	35,019	$4.73
*Arkansas	1	99,342	68,500	1.45
*Colorado	1	627,965	135,600	4.63
*Connecticut	1	666,983	141,008	4.73
Florida	1	....	....	....
Georgia	1	720,000	131,976	5.45
Kentucky	1	411,938	125,000	3.30
Louisiana	1	400,000	80,000	5.00
Mississippi	1	300,000	50,000	6.00
Montana	1	220,737	61,000	3.93
New Mexico	1	337,282	....	....
*North Carolina	1	660,000	153,000	4.31
*Oregon	2	1,034,605	118,615	8.74
Pennsylvania	1	2,504,672	....	....
South Carolina	2	....	....	....
*South Dakota	1	652,125	120,592	5.40
Washington	1	913,694	194,983	4.84

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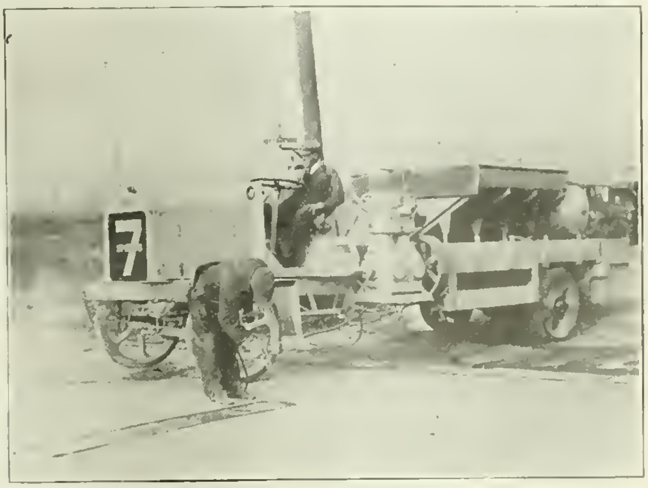
*Exemptions allowed on gas used for other purposes than motor vehicles.

Highway Maintenance Truck Has Many Uses

A highway maintenance truck having several novel features has been placed in operation on general road maintenance and other highway work in Road District No. 4 of Kern County, California. The equipment carried by the truck includes a rotary driven concrete mixer driven by an auxiliary shaft from the truck transmission; a 50-gal. tar or road oil heating tank with gas burners; a complete paint spray outfit; pneumatic jack hammer drill; air compressor operated by a belt from the truck's forward drive shaft; combination material bins having a capacity of 1,000 lb. cement, 1 cu. yd. sand and 2 cu. yd. gravel; and a pneumatic rotary post hole digger. The truck was designed and built by the Fageol Motor Co., Oakland, Calif.



Stenciling Sign on Highway.

A New 3-4 Yard Universal Shovel

The Bucyrus Co. of South Milwaukee, Wis., has just announced a new 20-ton ¾ yd. revolving shovel to be known as the 20-B. This shovel replaces the 14-B revolving shovel so long and so favorably known. From boom point to ash pan, this shovel is a distinctly new design. In general the design follows along the lines of the Bucyrus 30-G universal shovel, its bigger 1 yd. brother. It is a "Universal" machine, being adaptable to dragline, high lift, sewer, clam shell, crane and other combinations. The new features of this shovel include: A 2-part hoist; outside type of dipper stick and box girder type of boom; an improved A-frame directly connected to a steel center casting; a new dipper design in which all four corners are rounded; a double hinged latch lever; improved three lever control; and large boiler heating surface and grate area. The shovel is interchangeable from caterpillars to trucks or traction wheels. The shovel is equipped with an improved type of steer. For operation in the pit, where a pit man is always available, a simple and effective hand steer is provided. For moving from job to job a patented power steering wheel is provided.

New Bucyrus 20-B Shovel.

Safety Devices for Hauling on Industrial Track on Steep Grades

In constructing the Franklin Highway in Pennsylvania, a portion of the industrial track was laid with very heavy grades. As a consequence, safety devices were used. A description of these devices is given in the June Bulletin of the Associated Pennsylvania Highway Contractors by Mr. A. H. Sauerbrun, formerly superintendent of construction of the Pennsylvania Highway Department.

The cars were protected on the steep grades by automatic safety devices placed on the rear cars. This consisted of a 25-lb. rail, 30 ins. long with one end bent to an angle and pivoted to the coupling pin of the draw head. The other end dragging on the ground at an angle of about 40 degrees with the horizontal was split to a forklike shape and immediately dug deeply into the ground and held the train in position as soon as the tension was relaxed on the hauling line. This device was tested several times and always as soon as the tractor slacked off, or on another occasion when the tow line broke, it operated instantly to hold the cars fast, and after its adoption three or four miles of concrete was laid without any wrecks at all, thus eliminating what otherwise might have been a serious danger.

As soon as the switching engine of Pecan Siding delivered a train to the foot of the first grade, the 3-ton locomotive was detached and the 4-car train was hauled up the grade by one of the three 10-ton tractors which were kept always in service while two more, one at the bottom and one at the top of the long grade, were held in reserve. The tractors had abundant power to haul trains of more than four cars, but it was decided to limit the train lengths in order to avoid excessive stress on the tractors. When the tractors arrived at the top of the grade the full cars were attached to a locomotive waiting there and taken on to the mixer. In going down grade the tractor was attached in the same manner to the cars and idled along with the empty cars, which it delivered to the locomotive at the foot of the slope.

The cars were hauled up and down the slopes by tractors because the tractors were available from government supply, and because the lengths and steepness of the grades and the many curves in them would have made the use of a hoisting engine and cable very difficult and expensive. The trains were hauled up the 9,000-ft. slope at the second speed of the tractor. The system operated very satisfactorily and without any accidents or delays whatever.

Although the industrial track was laid with heavy grades, the 50 cars used on it for hauling to the mixer were not equipped with brakes. A simple scheme was therefore devised which provided an almost automatic and very efficient regulation of speed that was entirely reliable, inexpensive and simple, and prevented the occurrence of any accidents during the progress of the work.

The cars were hauled by the tractor in both directions to the top of the long grades between which the central station at Pecan Siding was located. At the tops of these grades they were hauled by the gasoline locomotive over grades up to 6 per cent, where the locomotive brakes were entirely inadequate to handle the trains. The locomotives were therefore supplemented by retarding shoes placed on the forward ends of the trains or locomotives according to the direction in which they were operating. The brake shoe consisted of a steel cradle with two ¾ x ½-in. flat bars, 18 in. long with the forward end curved 90 degrees over a 6-in. radius, about fitting the circumference of the wheel. These shoes were connected together by a pair of transverse drop bars offset downward to clear the wheel flanges and spaced to maintain the shoes to the track gauge so that one shoe would slide on each rail with the curved end forward. At the beginning of a downgrade, the engine driver dropped the cradle on the track in front of the forward car and the front wheels, immediately riding onto the shoe, coasted down the incline without wear or injury, and reduced the speed of the train so that it could be easily handled by the locomotive while the train descended by gravity. On very light grades the shoes, of course, were not needed because they could entirely stop the train. The cradles were made by the blacksmith at a very small cost and were entirely successful in preventing all accidents due to grades. They were not, however, required or used on the steepest slopes, where the trains were moved up and down by tractor hauling and were controlled as before described by a trailing safety device, of which ten or a dozen were provided and always kept in readiness at the incline. By this system, an economy in brakemen was effected and the flattening of wheels by locking was eliminated.

Examination for Valuation Engineer.—The U. S. Civil Service Commission, Washington, D. C., announces an open competitive examination for valuation engineer to fill vacancies in the technical staff of the income tax unit of the Bureau of Internal Revenue, Treasury Department, Washington, D. C., at $3,600 to $4,800 a year, and in positions requiring similar qualifications, at these or higher or lower salaries. The duties of these positions will involve the estimation of (1) the quantity of mineral or oil and gas or timber; (2) the theoretical and market values of mineral or oil and gas in places or standing timber, and their products; (3) the value of equipment ordinarily used in the discovery, exploitation, and utilization of such natural resources; (4) the cost of development, exploitation, and utilization of such natural resources.

3,000-Ft. Bridge Proposed for Carquinez Straits, California.—The San Francisco Transit Co. has secured right of way and has asked the War Department for a permit to build a 3,000-ft. suspension bridge, with 1,500-ft. center span, over Carquinez Straits, California. Charles Evan Fowler, Consulting Engineer, New York City; Edwin Duryea and H. L. Haehl, San Francisco, are the engineers.

Personals

L. H. Cunningham, of Oswego, Kan., has been appointed county engineer of Labette County, Kansas.

Creighton D. Bickley has been appointed highway construction engineer for Essex County, New Jersey, with headquarters at Newark, N. J.

R. W. Hodson, Clinton, Mo., has been appointed division superintendent of State Highway District No. 5, with headquarters at Jefferson City, Mo.

Rufus K. Sanders, Saltville, Smythe County, Virginia; Hugh B Sproul, Staunton; Wade H. Massie, Sperryville; L. Walke Truxton, Norfolk, have been appointed members of the State Highway Commission of Virginia. This completes the personnel of the commission. The chairman, Henry G. Shirley, having been previously named.

The firm of Holbrook, Warren & Andrew, Civil Engineers, Decatur, Ill., has been reorganized under the new name Holbrook, Warren & Van Praag. Major C. R. Andrew, the retiring member, is now consulting engineer for the city of Decatur, Ill. Alex Van Praag, Jr., the new member of the firm, has been assistant state sanitary engineer for the past 2¼ years, and as such has had exceptional opportunities to investigate and study water supply and sewerage problems for the State. The firm of Holbrook, Waren & Van Praag will specialize in municipal engineering with offices in the Millikin Bldg., Decatur, Ill.

Obituaries

Mrs. Anna B. Austin, wife of F. C. Austin, for many years one of the most prominent manufacturers of construction equipment in this country, died June 30 at Hamburg, Germany. Mrs. Austin had been living in Chicago for the past three years, but owing to continued ill health Mr. Austin decided to take her abroad for treatment. They had been in Hamburg only a few days when her death occurred.

A. S. Baldwin, vice president of the Illinois Central R. R., died June 27 while on a Michigan Central train en route from New York to his home in Chicago. Death was caused by heart failure. Mr. Baldwin was returning home from a three months' tour of Europe, where he studied railway electrification systems in preparation for his assuming charge of the Illinois Central's lake front improvements at Chicago. Mr. Baldwin started as a rodman with the old Richmond & Allegheny R. R. After 17 years' service with the Iron and Steel Works of Virginia, the Baltimore & Ohio and the Louisville & Nashville railroads, he came to the Illinois Central as assistant engineer. He later became chief engineer and then vice president.

Gamble Latrobe, general superintendent of the Southern Division of the Pennsylvania R. R., died June 21 at the Marlborough-Blenheim Hotel in Atlantic City. His death, which was very sudden, is attributed to heart trouble from which he suffered for the past three months. Mr. Latrobe was born in Baltimore, Jan. 21, 1866. He graduated from the College of St. James, at Hagerstown, Md., after which he attended the Massachusetts Institute of Technology. He began his work as an employe of the Baltimore & Ohio Railroad Co. and later went with the Philadelphia & Reading Railway Co. Leaving the latter company he became a rodman in the employ of the Pennsylvania R. R. and gradually rose step by step until Feb. 1, 1890, he was advanced to the position of assistant supervisor of the Philadelphia, Baltimore & Washington road. He was advanced by successive steps until on May 1, 1916, he was appointed to the position of general superintendent of the southern division, the position he held at the time of his death.

Industrial Notes

Spears-Wells Machinery Co., 211 12th St., Oakland, Calif., has been appointed an agency for the handling in Northern California of the sales of Smith concrete mixers, pavers and excavators and loaders made by The T. L. Smith Co. of Milwaukee, Wis.

Charles M. Schwab has been elected chairman of the board of directors of the Chicago Pneumatic Tool Co., succeeding John R. McGinley, who desired to retire from certain of his business activities, including the chairmanship. Mr. McGinley will continue to retain his active interest in the company by remaining on the board of directors.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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The Use of Chlorine to Remove Bad Tastes from Water

Chlorine has hitherto not been regarded as a remover of bad tastes from water. In fact, the usual experience has been that when microscopic organisms gave a taste to water, an application of chlorine made the taste worse. But now comes William W. Brush, Deputy Chief Engineer of the Bureau of Water Supply of New York City, with the statement that an excess of chlorine removes such tastes, whereas a normal dose of chlorine makes the taste worse. He says:

> The addition of chlorine to a water containing microscopic organisms has been generally found to increase the taste and odor, and it was therefore a surprise when in January, 1922, we found that by increasing the dose of chlorine the organisms were destroyed, and the taste removed. This discovery was made when tests were conducted to try to rid the Catskill water of a most objectionable taste caused by from 50 to 100 units of Synura per c.c. when the water was treated with a relatively small dose of chlorine. The smaller dose of chlorine killed some of the Synura and released the disagreeable oil contained by these organisms, whereas the larger dose attacked and neutralized the oil released by the destroyed organisms, as well as destroying the organisms. It was further found that when the organisms were first either wholly or partially destroyed by the use of copper sulphate in the aqueduct, that subsequent treatment of the aqueduct flow with chlorine would remove the taste from the water with a much smaller dose of chlorine than that required when the water had not been previously treated with copper sulphate. The amount of chlorine required with or without prior copper sulphate treatment was too small to cause a chlorine residual taste in the treated water. In general, a net increase of 0.1 of a part of free chlorine, as shown by the orthotolodine test on the raw and treated water, was sufficient to give the desired results. The orthotolodine test on the treated water is made about thirty minutes afer the chlorine is applied.

Mr. Brush has thus supplied waterworks men with a novel but simple means of overcoming a difficulty that has hitherto been baffling. Mr. Brush says:

> With the evidence now available of the successful destruction of microscopic organisms with either copper sulphate or chlorine, or a combination of these two substances, we hold that the water works superintendent can no longer consider the taste due to microscopic organisms as a visitation which cannot be controlled, and that his consumers have just cause for complaint if he fails to apply the remedy or remedies which have been successfully used elsewhere.

What Can Be Done to Secure Adequate Supplies of Pure Water?

Expenditures for waterworks extensions, enlargements and improvements are not adequate, and have not been adequate for at least seven years. Why? First, because the rates charged for water have not been high enough to provide a surplus for investment in plant. Second, because there has been no organized effort to convince taxpayers that it is cheaper to pay interest on additional waterworks bonds rather than to go without an adequate supply of pure water.

Waterworks superintendents and city engineers report periodically to city councils that water rates are too low and that more funds must be raised for plant improvement, but the average city council is dilatory about asking the consumer to pay higher rates and about asking the taxpayers to vote bonds.

There is need in most cities for some permanent organization that will examine all recommendations and endorse the good ones made by city engineers and waterworks departments. Without such support these city officials are frequently helpless.

The average newspaper pays little attention to recommendations made by city officials. The average taxpayer pays even less attention. So the average city drifts from bad to worse in its provision for an adequate supply of pure water until an extreme crisis forces the matter upon the attention of its people. Pumps grow old and inefficient and the load upon them increases. The pressure for fire purposes falls. Were it not for the National Board of Fire

Underwriters conditions would be even worse than they are in most cities, and they are certainly very bad.

Here is a splendid opportunity for the local chapters of national engineering societies to show the public the economic folly of persistently under building and under improving waterworks systems.

Such organizations could also show the public that nearly every city should be completely metered, as a matter of true economy.

A New Method of Treating Water with Copper Sulphate to Remove Tastes

Copper sulphate and liquid chlorine are the "gold dust twins" of the water supply engineer. Probably we are only just beginning to appreciate the possibilities of these twin destroyers of bacteria and micro-organisms. In another editorial we call attention to a recent discovery as to the removal of tastes from water by using an excess dose of chlorine. In this editorial we wish to speak of the possibility of freeing water from microscopic organisms and algae before it reaches the reservoir.

Copper sulphate ("bluestone") has proven its efficacy as a destroyer of these creators of bad tastes and odors in drinking water. But the custom has been to resort to the use of the "bluestone" only periodically and for a short time, instead of continuously. Now the water flowing into at least one reservoir is being dosed continuously with a solution of "bluestone." We refer to the dosing of the Catskill aqueduct by automatic feeding of a solution of copper sulphate into it at Croton Lake before it reaches the Kensico reservoir that furnishes part of the water for New York City. The dose is 2 lb. of "bluestone" per million gallons.

Most reservoirs are fed by small streams or pipes. Where this is the case and where either algae or diatoms are the cause of bad tastes, it would now seem wise to try dosage of the inflow with copper sulphate.

It is true that algae may not be detected as such in the water flowing into a reservoir, but none the less the spores or seeds of the algae may be carried into the reservoir by the streams that feed it. If so, is not the place to attack these trouble makers near the source rather than near or at the destination? Periodic treatment of a reservoir with "bluestone" is unquestionably effective, but may it not be far more effective to give the inflowing water continuous treatment? The answer appears to be yes, judging from the success that has attended the experiments conducted under the direction of Mr. William W. Brush.

Public Works Expenditures and Public Apathy Toward Needed Construction of Waterworks and Sewers

The following weekly summary was written by the editor of Engineering and Contracting for the Chicago Journal of Commerce.

Normally the total annual sales of municipal, county and state bonds (long term) equal approximately the total annual expenditures for public works. Since bonds are sold in advance of construction, the monthly sales of these bonds furnish an excellent means of forecasting the volume of public works construction.

During the first five months of 1913 almost $200,000,000 of municipal (including county and state) bonds were sold, which was a normal pre-war average. The following were the corresponding bond sales in round numbers for the first five months of the last five years:

1918	$135,000,000
1919	225,000,000
1920	300,000,000
1921	390,000,000
1922	585,000,000

About $110,000,000 of bonds were sold in the month of May, 1922, or nearly as much as during the first five months of 1918. Construction prices are now about 65 per cent higher than in 1913, so that the $585,000,000 of municipal bonds sold during the first five months of 1922 would buy no more construction than $350,000,000 would have bought in 1913.

Highway and building construction are decidedly supernormal in volume and show no signs of diminution. Waterworks, sewer, railway and traction line construction are badly subnormal, and have been so for years. Apparently city water and sewer departments have as yet been unable to secure adequate funds for extensions and improvements, because of public apathy and ignorance of the financial needs of those two departments.

Discretion in Enforcing Sewage Treatment

That every city and smaller community and every commercial plant producing liquid wastes should be required to treat its waste waters so as to bring them within a certain fixed limit of impurity was the idea of sanitarians of a short generation ago. In many cases in New England the effluents of sewage purification plants actually were purer than the streams into which they discharged. England established and re-established standards for effluents which were continually being found impracticable of enforcement.

A more reasonable and enforceable attitude, and one more logical from some points of view, is now taken by sanitarians and law makers. It is recognized that streams must receive drainage from their watersheds until natural laws are superseded by man-made ones, and cannot be kept "pure," and that the expense to which communities or individuals can be compelled to go to reduce the amount of pollution they contribute to the streams must be determined by reasonable consideration of the special conditions affecting each case.

The requirements made of some communities, such as those which drain to streams that must be used as a source of water supply, must be more stringent than are necessary in the case of others, such as those draining into salt water or the lower courses of streams already polluted. To draw up laws and regulations that will fit all cases would be impracticable, for each case differs in some respects from almost every other, conditions are continually changing and a standard set of a given city today will not be suitable in five or ten years from now, and knowledge and practical possibilities are continually developing along old and in new directions.

The making and enforcement of regulations governing sewage treatment must therefore be placed in the hands of some commission or individual who is granted powers of discretion in adapting them to individual cases. These administrators of the sanitary powers of the state therefore occupy a very responsible position and one calling for a degree of judgment and wisdom not demanded of most public officials.

It is very gratifying to know that one of our most populous states, and one in which stream pollution problems are especially difficult of satisfactory solution, has so wisely selected the members of its state health department. Their attitude toward this question is stated clearly and at length in this issue. It is based upon "an economic consideration of the uses and conditions of the various waters of the state so as to secure the greatest protection to the public health by the least expenditure of public and private funds for construction and operation of water purification and sewage treatment works."

Too often state as well as local health departments are placed in charge of physicians who consider their duties to stop with securing "the greatest protection to the public health" and who fail to give any consideration to "expenditures of public and private funds" as something in which they are in no way concerned. In the end the public health will receive much greater protection from the Pennsylvania type of health department than from the narrower-minded ones which encounter opposition at every step because of their inability to realize that even health work is inter-related with public finances and can not expect all other interests to give way to it, or to the present officials' idea of how it should be conducted.—Editorial in Public Works.

New England Waterworks Association Convention.—The 41st annual convention of the New England Waterworks Association will be held at New Bedford, Mass., Sept. 12, 13, 14 and 15.

Is the Ether Mythical?

By HALBERT P. GILLETTE, Editor.

When Einstein first announced his theory of relativity he he did not deny the existence of ether, but later on he began to contend that ether is a mythical conception and entirely useless. This attitude toward the ether hypothesis has been adopted by a good many physicists and by some engineers, a notable example of the latter being Charles P. Steinmetz, the celebrated electrical engineer and mathematician. On the other hand, many eminent scientists are, like Sir Oliver Lodge, who finds it impossible to explain the phenomenon of light satisfactorily without conceiving an ether that transmits the waves of light.

Steinmetz, in a recent article in "Popular Radio," contends that no electrical engineer has found it necessary to explain electrical phenomena by the aid of ether, and since light is an electromagnetic phenomenon, it follows that even light phenomena are explainable without the aid of ether. He says:

> The logical error, which led to the ether theory, is the assumption that a wave must necessarily be a wave motion. Electrical engineering has dealt with alternating currents and voltage waves; it has calculated their phenomena and applied them industrially, but it has never considered that anything material moves in the alternating current wave and has never felt the need of an ether as the hypothetical carrier of the electric wave. When Maxwell and Hertz proved the identity of the electro-magnetic wave and the light wave, the natural conclusion was that the ether is unnecessary also in optics. But curiously enough, we then began to talk about electric waves in the ether and about ether telegraphy. In other words, we dragged the conception of the ether into electrical engineering, where it never had been found necessary before.

In his enthusiasm Steinmetz has overstated the case, for whole books exist in which electric phenomena are discussed from the standpoint of the believer in the ether hypothesis. The truth, therefore, is that many, probably most, physicists still adhere to the ether hypothesis.

Steinmetz, following Einstein, says that he substitutes the "magnetic field" for the vibrating ether, and that he finds it wholly unnecessary to conceive an ether in order to explain electric waves. He says:

> To produce a field requires energy, and this energy is stored in the space we call the field. . . . The space surrounding a magnet is a magnetic field.

But he fails to show how energy can be "stored" in empty space, and until some one is capable of giving us some sort of mental picture of such a process of storage, it will be entirely unsatisfactory to most of us to assert that no ether is needed to explain a "field of force."

The advocates of a non-etherial field of force have made the logical blunder of regarding a term or phrase as being an explanation. Words are but symbols of things, so that merely substituting "field of force" for etherial waves will not suffice. A scientific explanation consists in showing a kinship or likeness, and there is no doubt that light waves are akin to electric waves in a "field of force." But the believers in ether are not content to stop with this kinship. They go farther and point out that light waves are akin to sound waves in many respects, such as reflection, refraction, etc. In fact, it was this kinship between sound and light that led to the conception that there is a sort of very tenous "air" throughout the universe, to which the name ether was applied. This conception of ether when once formed led to astonishing progress in the science of optics (see Whewell's History of the Inductive Sciences, Book IX, History of Optics). The ether hypothesis then became so firmly established that it ceased to be called a hypothesis and took its place among established theories.

We have now a peculiar but not unprecedented case, of a science built to a high degree of mathematical exactitude upon a theory that is suddenly declared to be illogical! It will take, I think, a deal of argument to overthrow a theory that has been so amazingly fruitful. Up to date the only argument against the ether theory is that some mathematicians, physicists and engineers claim to be able to get along without it. It will be well to examine those claims very carefully. It often happens that in the very words with which a man denies the existence of a phenomenon he tacitly admits its existence. Herbert Spencer, in his Psychology, gives many examples of metaphysical arguments in which the verbal denial of a class of thing contains in the conception of the words an acknowledgment of that very class of thing. Thus when the metaphysician says that a universe is conceivable in terms of mind apart from matter, his every word implies matter and cannot be conceived apart from matter.

Similarly when Steinmetz says that an electromagnetic wave occurs in a "field of force" where there is no substance such as ether, he uses a word, namely wave, that is inexplainable except in terms of some substance that waves. Try to picture a wave in void space. It cannot be done. Try to picture motion apart from a substance that moves. It cannot be done. Try to picture energy apart from a moving substance. It cannot be done.

There are still many who teach that energy may be "potential" and not "kinetic," but the fact is that potential energy is inexplainable except in terms of balanced kinetic energies.

So when it is affirmed that waves in a field of force exist, it is tacitly conceded that there must be some substance (call it ether or what you will) that is moving; for if this concession is not tacitly made, then it follows that "field of force" is a thing wholly unlike every other manifestation of mechanical energy, in existing without any substance that acts or reacts. If so, it has no kinship and is therefore unexplained.

Many mathematicians are prone to rest content with their symbols and functional relationships, without seeking to picture the things that the quantities relate to. But there is another type of mind that is not satisfied with symbols and quantities, and demands a picturing or explaining. It is this type of mind that demands anetherial substance that transmits light and electricity waves. Lest it be considered that this visualizing and explaining type of mind is inferior let me recall the fact that Isaac Newton's mind was of this visualizing type. He not only conceived that there must be an ether to explain gravitation, but he asserted that conception of gravitation without an ether is impossible. In his Logic, John Stuart Mill ridicules Newton's statement; but Mill fails to define "conception" and so does Newton, so that Mill probably had in mind conception apart from explanation, whereas Newton unquestionably had in mind an explanatory conception. In that sense of conception, Newton was right; for no transmission of energy can be explained by a conception that does not involve substance in motion.

To assert that Einstein's theory of relativity does away with the necessity of etherial substance is to assert more than can be proved. Relative motion itself implies substances that are moving. Hence, relativity is inconceivable apart from substance. What warrant, then, is there for appealing to relativity as a reason for discarding the substance called ether? Not the slightest.

The great forward steps in pure science have nearly all been taken by men who perceived an analogy (likeness or kinship) between two classes of things, and have conceived that the partial likeness perceived probably indicated other likenesses as yet unperceived. It was the application of just this sort of reasoning that led to the conception that light is similar to sound in being transmitted in waves by a substance whose particles are free to move. There are, it is true, differences between air and ether, but may not these differences arise entirely from differences in the velocity and paths of their particles? It can be shown that sound travels through air at a velocity that is 70 per cent of the velocity of the molecules of air. Is it not probable that the particles of ether move at a somewhat greater velocity than the velocity of light? May it not be that some of the differences between sound and light phenomena are attributable to the fact that the vibrating particles of air move in very elongated ellipses whose long axis is in the direction of the wave motion, whereas in the case of light the short elliptical axis is in the direction of wave motion? Thoughts such as this arise from the conception of ether as being like air, yet differing in certain respects; and it has been the testing out of just such ideas that has hitherto led to great progress.

Non-etherial hypotheses, if applied exclusively, would put a stop to future tests of the truth of deductions drawn from an etherial hypothesis; and, based on the history of optics, non-etherial theories were fatal to the progress of that science.

A non-etherial hypothesis may be fruitful, but its advocates have neither historical nor logical justification for ridiculing an etherial hypothesis.

So long as such a vast array of facts are explained satisfactorily by the ether hypothesis, and by no other hypothesis that does not tacitly involve a substance that waves, it is illogical to contend that ether is mythical.

Our senses do not perceive anything in its ultimate form. All that we perceive is effects of causes that are beyond direct perception. This is as true of the substance called copper as of the substance called ether.

Steinmetz says:

> Our lack of familiarity with the conception of an energy field in space and our familiarity with the conception of matter as the carrier of energy may lead to the question: What is the carrier of the energy of the field of space? Would not the ether be needed as a carrier of the field energy, just as on the older theory it was needed as a carrier of the hypothetical wave motion of matter?
>
> These questions are due to a mental error. Familiarity reverses the relation between primary and secondary conceptions.
>
> All that we know of the world is derived from our senses. They are the only real facts, everything else is conclusions from them. All sense perceptions are due to energy; they are exclusively energy effects. In other words, energy is the only real existing entity. It is the primary conception, a conception which exists for us only because our senses respond to it. All other conceptions are secondary conclusions, derived from the energy perceptions of our senses. Thus space and time and motion and matter are secondary conceptions with which our mind clothes the events of nature.
>
> Obviously, then, by carrying the explanation of light and electromagnetic waves back to the energy field—to energy storage in space—to the electromagnetic field, we have carried it back as far as possible. We have carried it back to the fundamental conceptions of the human mind; the perception of the senses.

With the idea that "energy is the only real existing entity" few scientists will quarrel. But I do object to the conclusion that there are any other conceptions than those that involve energy. Space, time and motion are not secondary or derived conceptions, but are themselves essential "parts" of any conception of energy.

It is true that there is nothing more fundamental than energy; and it is in terms of energy—something in motion—that the ether hypothesis of light and electricity explains these phenomena.

The real difference of opinion between the relationists and the etherists is that the former rest content with a partial explanation, and that the latter seek a fuller explanation, a carrying of the relationship between light, electricity, sound, etc., to a closer degree of kinship.

Municipal Water Consumption in Western Canada

The accompanying tabulation from the 1920-21 report of the Canadian Reclamation Service shows the average daily per capita water consumption in 1920 for the principal cities and towns in Alberta and Saskatchewan:

	Population.	Per head for domestic purposes.	Per head for industrial purposes.	Per head for other purposes.	Per head for all purposes.
Bassano, Alberta	1,000	....	....	....	158.9
Carmangay, Alberta	400	26.2	....	3.4	30.3
Athabaska, Alberta	400	41.3	....	....	41.3
Edmonton, Alberta	60,000	54.7	23.1	16.2	94.3
Lethbridge, Alberta	12,000	91.8	35.1	6.8	129.1
Medicine Hat, Alberta	11,000	....	....	....	206.8
Redcliff, Alberta	2,200	67.9	16.2	....	84.2
Estevan, Sask.	....	9.3	4.4	....	13.7
Kindersley, Sask.	....	6.9	17.5	....	21.5
Moosejaw, Sask.	23,000	24.5	14.5	....	39.1
North Battleford, Sask.	4,000	11.4	5.8	5.9	*34.0
Regina, Sask.	40,000	18.9	9.1	.9	58.8
Saskatoon, Sask.	28,000	29.4	14.3	6.1	†74.1
Weyburn, Sask.	4,000	30.2	....	....	30.2

*Includes 10.9 gal. unaccounted for. †Includes 24.4 unaccounted for.

Cost of Water Mains at Council Bluffs, Ia.—The following table reprinted from the report of the Board of Waterworks Trustees of Council Bluffs, Ia., shows the cost of new mains laid in 1921, including hydrants and valves:

2 in. galvanized pipe, cost per lin. ft. complete	$0.415
6 in. cast iron (Class C) per lin. ft. of pipe	1.552
8 in. cast iron (Class C) per lin. ft. of pipe	2.163
10 in. cast iron (Class C) per lin. ft. of pipe	2.594
8 in. repaving, per lin. ft. of pipe	19.15
10 in. repaving, per lin. ft. of pipe	22.30

Popular Presentation of Analytical Results

By HARRISON P. EDDY,

Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

Large numbers of chemical, bacterial and microscopical analyses of water supplies and effluents from sewage treatment plants are being made by state health departments, municipalities and other interested parties. In some cases analyses have long been made at regular intervals and there are masses of analytical data which are very valuable for those who have the ability and the time to make extended research.

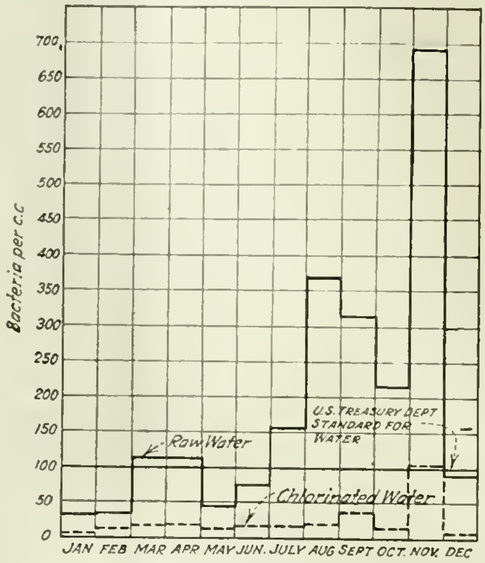

Fig. 1.—Quality of Raw and Chlorinated Water. Index = Bacteria Growing on Agar at 37° C.

In most cases, the analyses have been made for the purpose of keeping track of the quality of the water supply or the sewage effluent in order to ascertain if the water is of proper quality, and if not, what steps could be taken to improve conditions. In some cases, state health departments have regularly reported the results of analyses to officials in charge of the works under examination, with the expectation that such officials would thus become better informed and be guided in the operation of their works.

Sometimes results expressed in numbers have been sent without reference to preceding analyses. Often little or no explanation has accompanied the analyses. At intervals some departments have published tables of analyses from which operators could obtain information regarding the results obtained by them and by others having in charge similar plants. In order to benefit by such tabulations, an operator must have the technical knowledge and interest to make a more or less detailed study of results. Such studies often involve considerable labor and are difficult and uninteresting to the average operator without technical education.

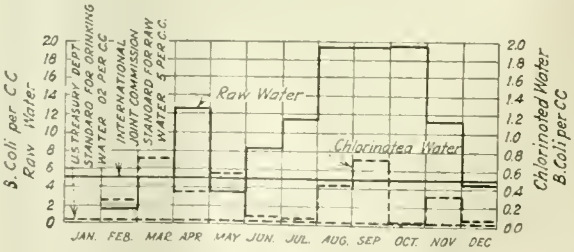

Fig. 2.—Quality of Raw and Chlorinated Water. Index = B. Coli.

Valuable as are the results of analyses compiled in the usual way, they could be made of much more service if they were to be presented in a manner to attract the attention and invoke the interest of the plant operator. The preparation of reports in such a manner would often make the analyses of more value to the one making them or having supervision of the works by enabling or enforcing him to make comparisons with past records.

The interpretation of analyses obviously should be based upon full knowledge of the source of the water supply and of the manner of treatment of the water or the sewage. Reports should bring pointedly to the attention of officials in charge the necessity of improvements when such necessity exists.

Where analyses are regularly made or where a number of similar analyses have been previously made, the report may well include a tabulation of some of the results of preceding analyses in order that the official may compare the results of the analyses under consideration with those formerly made.

Officials are often interested in the operation of other neighboring plants and reports including the results of analyses of such waters or effluents for comparison with those under consideration may be helpful.

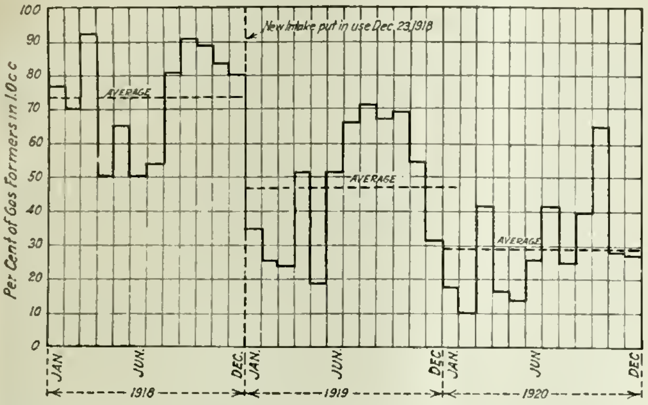

Fig. 3.—Quality of Raw Water. Monthly and Annual Averages of Analytical Results.

While for the purpose of the records, analyses may properly include determinations which are of little value as a guide in operation, they should also include determinations of special significance and the results of these determinations should be emphasized in the report. The selection of the determinations to be made obviously depends upon the character of the water supply, and the treatment to which the water or the sewage is subjected. In many cases, a very few determinations will afford important information to the operator.

One method of popularizing analyses is to accompany the report giving the actual numerical results, with one or more diagrams. This method is illustrated by Fig. 1, which will enable the operator to follow the changes in the character of the raw water, to note at a glance the improvement in quality due to chlorination, and to compare the bacterial content of the chlorinated water with the U. S. Treasury Standard. The diagram can be prepared on tracing cloth and extended from month to month as the results are obtained. Prints can be sent to the operating official at regular intervals so that he may be promptly advised of conditions. Such prints will enable him to compare readily current results with those previously obtained.

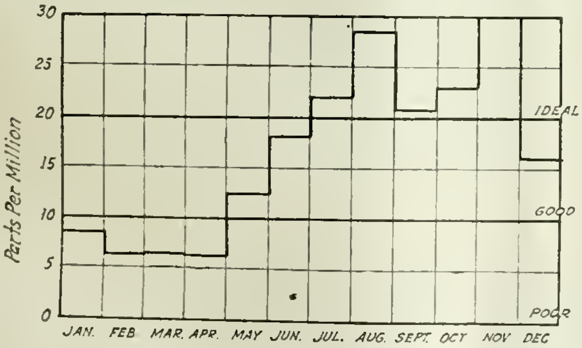

Fig. 4.—Quality of Effluent from Intermittent Sand Sewage Filters for Climates Having Moderately Uniform Temperature. Index = Nitrates.

Figure 2 is another illustration of this method of presentation. Such a diagram enables the operator to note the changes in quality of raw water, compare its quality with the standard of the International Joint Commission, observe the improvement in the raw water resulting from chlorination and compare its quality with the U. S. Treasury Standard. Such comparisons will take but a moment of his time, but they will give him a clear understanding of the bacterial quality of the water and encourage his attention to the necessity of improvements, if any such need exists.

Diagrams showing results of routine analyses should have noted upon them changes in physical or operating conditions in order that their effect may be observed. Fig. 3 illustrates, among other things, the effect of change in intake. This figure also shows the annual averages which can be indicated on the diagram only at the end of the year, but thereafter serves a useful purpose in enabling comparison with current conditions.

A diagram like Fig. 4 gives an interpretation of the results as well as their numerical values. In preparing such a diagram, the scale of quality should be carefully selected in the light of any peculiar conditions which exist at the plant. It is important, also, that they should be so selected as to encourage, rather than discourage, the plant operator. For example, it is better to fix the "ideal" standard for the plant in question low enough so that the quality of the water or effluent may occasionally be superior to the standard than to fix such an "ideal" so high that the operator cannot hope to attain it.

In many cases, the quality of the water or of the effluent depends upon seasonal conditions and a standard quality cannot fairly be represented by a straight horizontal line. A report recognizing this condition can be made in form illustrated by Fig. 5, which will show the operator what results he may properly expect from time to time, as well as the results which he actually obtains.

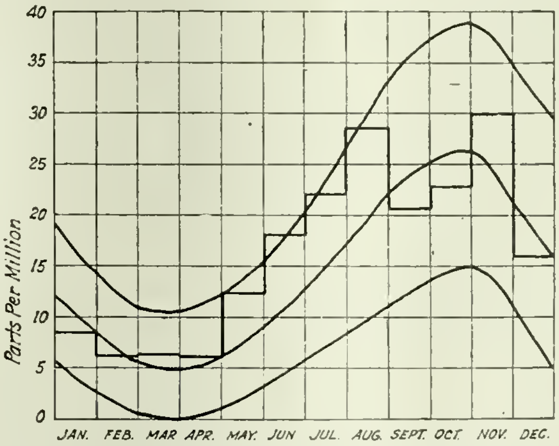

Fig. 5.—Quality of Effluent from Intermittent Sand Sewage Filters for Climates Having Variable Temperatures as in New England. Index = Nitrates. Upper Curve, "Ideal"; Middle Curve, "Good"; Lower Curve, "Poor".

It may be argued that the preparation of reports in the form suggested will increase the cost of this class of work. However, the writer does not feel that this is an important objection to the popularizing of such reports. As a matter of fact, the added expense cannot be a large item, and the increase in value resulting from encouraging the interest of the operator will far outweigh such additional cost as there may be. In many cases, it is probable that the work can be rearranged or some determinations omitted in order to permit of compiling results in this manner at a cost no greater than that involved in present methods.

A Correction

Two typographical errors occurred in the artile "Discharge Capacity of Wood Pipe and Formulas for Calculating Flows" in our June 14 issue. Formula 1 on page 565 should have been

$$Q = \frac{.3927\, D^2\, H^{\frac{1}{2}}}{\sqrt{\frac{L}{C^2} + .00582D}}$$

and formula 2 on page 566

$$q = \frac{508.9\, d^{\frac{5}{2}}\, H^{\frac{1}{2}}}{\sqrt{\frac{L}{C^2} + .000485\, d}}$$

Run-Off Percentage Used in Sewer Design

In a discussion* of a paper before the Municipal Engineers' Society of the city of New York, Mr. Kenneth Allen, Sanitary Engineer, Board of Estimate and Apportionment, New York City, gave the following run off percentages used in sewer design by different cities or computed from actual gagings.

Buffalo, N. Y.—George H. Norton, City Engineer, writes of a 14,500-acre watershed, of which 10,500 acres are in farmlands outside the city, for which 60 per cent was used inside the city limits and 25 per cent outside. In a certain residential area 40 per cent is being used.

Louisville, Ky.—J. B. F. Breed, Chief Engineer, Commissioner of Sewerage, says that up to last August the McMath formula had been used, with co-efficients of from 0.60 to 0.75. Metcalf and Eddy have adopted the following co-efficients in planning for future work at Louisville:

Duration of Precipitation—Minutes	Run-off co-efficient for zone after duration stated Impervious surfaces.	Run-off co-efficient for zone after duration stated Previous surfaces.
5	0.50	0.10
10	0.60	0.20
20	0.80	0.35
30	0.85	0.40
15	0.90	0.45
60	0.95	0.50
180	0.95	0.70

San Francisco, Cal.—For downtown districts uses 85 per cent.

Cincinnati, O.—H. S. Morse, Engineer in Charge, and H. P. Eddy, Consulting Engineer, generally used 70 per cent for completely-developed districts, but in special cases as high as 85 per cent.

Boston, Mass.—Careful studies of the Back Bay (chiefly residential) district were made by Kuichling and Bryant and by the Sewer Division. For four sub-districts the former recommended co-efficients of from 61.8 to 72.3 per cent† and the latter of from 69.3 to 88.8 per cent. At present F. A. Lovejoy, Engineer of Design, states that a resultant co-efficient is reached from assigning the following factors to component areas:

	Per cent.
For roofs, granolithic, asphalt, etc.	95 to 100
For good macadam, brick sidewalks, etc	70 to 90
For dirt or clay yards, roadways, etc.	20 to 70

The resultant is then multiplied by the "retention factor" $\frac{100\,t}{t+3}$ in which t = time in minutes from beginning of storm.

Detroit, Mich.—Clarence W. Hubbell, City Engineer, writes: "The co-efficient used varies according to the character of building from about 30 in residence areas, where the lots are large, to about 95 in the built-up downtown sections."

Cleveland, O.—George B. Gascoigne, Sanitary Engineer, Department of Public Service, writes: "For the downtown sections of the city a co-efficient of 1.0 is used while for the residential area a co-efficient of 0.6 is used."

St. Louis, Mo.—W. W. Horner, Chief Engineer of Sewers and Paving, says: "For business districts, which are practically impervious, we are using co-efficients up to 90 per cent for an hour, and slightly more for larger rains."

Philadelphia, Pa.—John E. Allen, Assistant Engineer, Sewer Plans and Sewage Disposal, says: "It is the practice in this division to use a 90 per cent factor for imperviousness in the central city district of solidly built and paved surfaces and tall buildings. It should be noted that the addition of the normal sewage flow will frequently cause a run-off exceeding 100 per cent of the rainfall, and this should be taken into account when proportioning sewer capacities. Outside of the central city, with ordinary commercial and residential development, a co-efficient of 75 per cent is in use. In suburban districts, such as Oak Lane and Chestnut Hill, with macadam streets, grass lawns and unpaved yard spaces, the co-efficient is further reduced to 60 per cent. The run-off from city squares and park areas is taken at 30 per cent."

Twelve Other Cities.—Charles E. Gregory, the late president of the Municipal Engineers Society, recommended the formula $0.175\,t^{1/3}$ for impervious surfaces, which gives:

t = time of collection in minutes	20	30	60	120
c = per cent run-off	48	55	68	86

The maximum percentages recommended by other authorities are: W. C. Parmly, 100 per cent; A. P. Folwell, nearly 100 per cent; Karl Imhoff, 80 per cent; Wilhelm Voit, 100 per cent, while the following percentages have been recorded:

Rochester, N. Y.	58.2%.	E. Kuichling
Omaha, Nebr.	60.6%.	Alvah Grover
Chicago, Ill.	78%.	L. K. Sherman
London, Eng.	94%.	quoted by Baumeister
Birmingham, Eng.	96-126%.	quoted by Metcalf & Eddy
Cambridge, Mass.	100%.	quoted by Metcalf & Eddy
Washington, D. C.	100%.	quoted by Metcalf & Eddy
Wilmington, Del.	79%.	quoted by Metcalf & Eddy
Pawtucket, R. I.	87%.	quoted by Metcalf & Eddy
Philadelphia, Pa.	98%.	quoted by Metcalf & Eddy
Rochester, N. Y.	65%.	quoted by Metcalf & Eddy
Hartford, Conn.	100%.	quoted by Metcalf & Eddy

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*First quarterly issue, 1922, of The Municipal Engineers Journal.

Wire Drag Sounding Line

How soundings are made with a wire drag line is described by Maj. W. B. Harrison, Corps of Engineers in The Military Engineer, from which the notes that follow are taken.

Construction of the Line.—Assuming the depths to be measured in the particular case are from 18 ft. to 33 ft., the line is constructed as follows: Starting with an ordinary 8-lb. sounding lead fitted with a short leather thong, attach one piece of No. 14 galvanized wire with a small eye in the free end, to make over-all length from lower end of lead to the eye at free end 18 ft., then 7 lengths of No. 14 galvanized wire, each 1 ft. long over their eyes, making an over-all length of 25 ft. In the last eye (25 ft.) bend in 10-ft. length of shrunken ¼-in. cotton line, making total over-all length 35 ft. The line is then marked thus: At the 18-ft., 24-ft., and 30-ft. distances, small pieces of black muslin are tied in the eyes or sewed on the line. At 21 ft., 27 ft., and 33 ft., small pieces of red muslin are tied in the eyes or sewed on the line. At all the other foot marks, small pieces of white muslin are tied in the eyes or sewed on the line. The eyes in the wire should be made no larger than is necessary to allow hinge action, and the markings should be no longer than is necessary for the leadsman to see readily, because the eyes and markings all offer resistance to currents and tend to cause sag in the line. Tenths-of-foot between the foot marks can, after a little practice, be quite accurately estimated. Lines to measure lesser or greater depths are made on the same principle, viz: Wire length at maximum and rope length at minimum. The rope length serves as a handle, enabling the leadsman to obtain a satisfactory grip on the line without cutting his hands on the wire.

How the line is Used.—The leadsman stands on the stern of the sounding boat, preferably a row boat, holding the line overboard continuously with the lead a foot or so above the river bottom. The boat is propelled at a rate of 2 to 3 miles an hour, and when soundings are required the line is lowered to the bottom, the foot mark above or below water line noted, the tenths estimated and added or subtracted from the noted foot mark below or above the water line, as the case may be. A forward and after swing of the leadsman's arm will usually bring the lead directly under the stern of the boat, making the measurement vertical, but in case this method does not give a truly vertical measurement the slant in the line is observed and the boat is checked and backed up, so that the line becomes truly vertical. The difference between the slant line and vertical-line soundings will give the error for slant-line sounding, which should be recorded for each line as is done with tide readings, and applied to the observed soundings to reduce them to their proper datum values.

Rapidity and Accuracy of Method.—With the wire line, soundings may be readily obtained at 10-ft. intervals, and their accuracy in deep water exceeds those obtained from a sounding rod, due to increased sensitiveness of touch on the river bottom. The flotation of the sounding rod deadens the sensitiveness of touch, so that in soft material the heel of rod has to penetrate the soft mud before the leadsman is aware that he has touched bottom. In the method of the ordinary casting line, the soundings obtained are always excessive, due to the three principal errors of the method: (1) Line not vertical; (2) lead sinking in soft material or lying on its side; (3) the catenary form taken by the ¼-in. line due to its resistance to currents.

The wire line will consistently give 4 per cent to 8 per cent less than the ordinary casting line.

The wire sounding line for depths greater than 16 ft. (for depths less than 16 ft. a sounding rod is used) has been used exclusively in the Washington District for twenty years.

Copper Sulphate Treatment for Preventing Algae Growths in Lakes and Reservoirs

Experiences at Fairmount, Minn., Described in Paper Presented at 1922 Meeting of Minnesota Surveyors and Engineers' Society

By N. L. HUFF,

Assistant Professor of Botany, University of Minnesota.

For our purpose here we may divide the fresh water algae into three classes, according to their general habit of growth or their vertical distribution. The first of these classes consists of those forms which are attached to the substratum, or if free, are heavier than water and therefore rest upon the bottom. Having a definite light and oxygen requirement they are largely confined to shallow water. In fall and spring the vertical currents may stir up some of these forms thus increasing the turbidity of the water. In general, however, this class is of little concern in lakes and reservoirs.

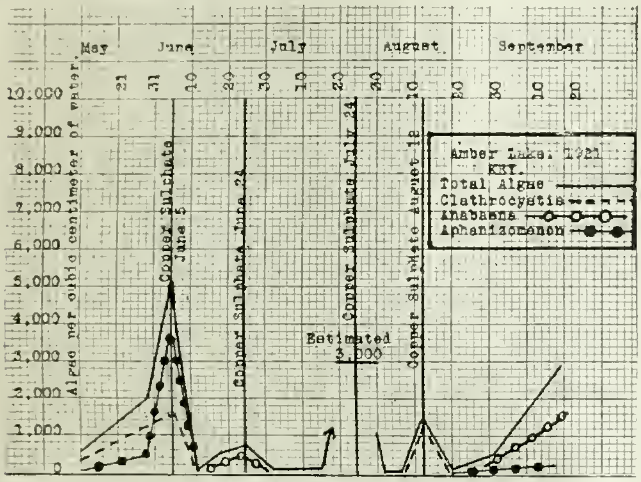


Fig. 1.—Effect of Copper Sulphate Upon Algae in Amber Lake.

The second class includes free-floating forms with specific gravity practically the same as that of the water. They float beneath the surface and are usually rather uniformly distributed from the surface to a depth of 20 to 25 feet. Their growth and development is but little affected by winds and rough water and they thrive in larger lakes as well as in small. They follow the water currents and the depth at which they may be found in abundance depends upon the depth to which the water is stirred by winds. This is seldom more than 20 or 25 feet and these forms apparently thrive as well at that depth as at the surface. When abundant they give a greenish or brownish color to the water. They do not often produce scums but the turbidity which they give to the water may impair its quality for the laundry, to say nothing of its use for other domestic purposes.

Scum Formers Most Troublesome of All the Algae. The third class is the scum-forming class and the most objectionable of all. It includes those free-floating forms whose filamentous masses often collect within their meshes quantities of gases that buoy them up to the surface where they form the familiar green slime. It includes also those blue-green forms in which individuals are often associated in colonies just visible to the unaided eye. These colonies appear as greenish flocculent masses near the surface, in perfectly still water coming to the surface and forming the familiar "water-bloom." In the open water of larger lakes these surface-loving forms do not thrive and seldom become sufficiently abundant here to cause annoyance. But in shallow and protected bays, and in small lakes and ponds they find conditions ideal for their growth and development. Especially suited to their mode of life is the lake or pond containing many pond weeds, rushes, and other aquatic plants that temper the wave action and afford harbors for growth and reproduction of these fragile microscopic forms. Another condition of shallow water commonly favorable to scum-forming algae is the rather high temperature reached by such water during the warmer months. Many of these forms will not thrive at all in cold water but under favorable conditions of temperature and light they increase with astounding rapidity.

The Blue-Green Scum Formers.—The blue-green scum-formers are perhaps most troublesome of all our algae. The first sign of the appearance of some of these blue-green scums is the appearance near the surface of tiny greenish flocculent masses, or if the surface is very smooth the first evidence may be seen in a very delicate "bloom-like" film on top of the water. If the weather is warm and calm the delicate film increases at a rate that is almost unbelievable. It is not uncommon for some of these forms to double their number in 24 hours or less, and within a week after they first become visible to the unaided eye the whole surface of the lake may become green as if it contained some soluble green paint. If the winds are light so as to carry these surface forms to the shore without breaking them up or mixing them with water of greater depths, a scum is formed that may have somewhat the consistency of a stiff green paste. The fragile forms responsible for the scum are very delicate and when conditions become unfavorable for growth they die and disintegrate very rapidly. Needless to say that where the growth becomes so luxuriant, conditions cannot remain favorable for all of the individuals of the little masses or colonies and one always finds in examining such growths, a large per cent of the colonies in various stages of disintegration.

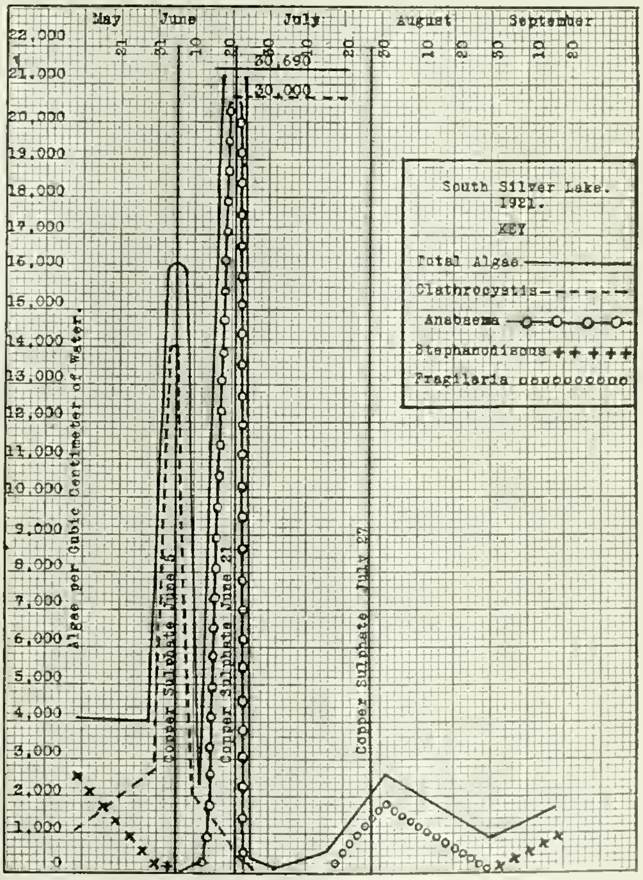


Fig. 2.—Effect of Copper Sulphate Upon Algae in South Silver Lake.

The odors that are given off by some species when in apparently good growing condition, are anything but agreeable, but with the gases that accompany decay, the stench may become almost unbearable.

Must these conditions be endured year after year by a community so fortunate as to have within their midst a beautiful lake? Is an expensive filtration plant or the digging of wells the only recourse in case the community's water supply becomes so contaminated with algae? Must summer resorts close up in July or early August for the remainder of the season because the lake has ceased to be attractive for bathing and fishing? What can be done?

Several questions may be asked when conditions of this kind arise in a community (1) Does the community want to remedy the condition? (2) Can it be done? (3) If so, how can it be done? (4) What will it cost?

The answer to the first of these questions will of course depend upon the community. In most cities, towns, and villages of the state, there is a certain civic pride and there are enough public spirited citizens to accomplish the desired result if the public is awakened to the condition, and an interest is aroused in improvement In answer to the second and third questions we may say that it can be done by use of copper sulphate, and if the application of this chemical is properly supervised there is no danger to fish or other animal forms of the lake, nor does it impair the quality of the water for domestic uses including drinking. Concerning the fourth question, the cost, of course, will depend upon the number, size, and depth of lakes, and upon the particular organism responsible for causing the trouble In general it may be said that the costs are not excessive, and are usually within easy reach of the average aggressive town or village.

How the Copper Sulphate Is Applied.—The method of applying copper sulphate is extremely simple and no expensive method is required. Crystals of the commercial copper sulphate or blue vitriol are placed in a coarse burlap sack such as an ordinary gunny sack and this is towed behind a rowboat or at the side of a small launch until the crystals have dissolved. Care must be taken of course that boats go in definite paths to insure the even distribution of the chemical, otherwise certain parts of the lake may escape the effects while other parts are given an overdose which might result in killing fish and other animal forms. By rowing slowly 100 lbs. of copper sulphate may be easily dissolved in an hour. With a small motor boat from 250 to 300 lbs. of the chemical can be dissolved in the same length of time. Where parts of the lake are too weedy or too shallow to be accessible by boat, the distribution of copper sulphate by means of a small sprayer such as is used for spraying fruit trees has proven very successful.

Amount of Chemical Required.—The quantity of copper sulphate required to eliminate algae depends upon a number of conditions. The kind of organism causing the trouble is one of the most important matters to be determined before using the chemical. Some of the most troublesome forms may be destroyed with one part of copper sulphate to 10,000,000 parts of water. Other forms require ten, twenty, or even fifty times that amount for their destruction. The temperature of the water is another important factor to be considered. An amount of copper sulphate giving satisfactory results in mid summer when the water temperature is 75° or 80° F. may be wholly inadequate in September or October when the water temperature has lowered to 50° or 60° F. The quantity of organic matter in the water is another factor greatly affecting the amount of copper sulphate needed. Water containing much organic matter requires a greater quantity of copper sulphate to bring about desired results. The hardness of the water and the amount of carbon dioxide which it contains are also factors that should be given consideration.

Effect of Treatment on Fishes.—Before treating a lake one should know what kinds of fish inhabit its waters. The amount of copper sulphate which certain fish are able to endure is less than that required for the destruction of certain of the more hardy species of algae, and if care is not taken fish may be destroyed in attempting to eliminate these more hardy algal forms. Fortunately the most troublesome algae are more susceptible to copper than are the fish, so that if proper precautions are taken the algae may be removed without endangering the lives of the fish or other animal organisms present.

The following table, based largely upon the report of Moore and Kellerman (Bull. 76, Bur. of Plant Industry, U. S. Dept. of Agr. 1905) may serve to give a general idea of the quantity of copper sulphate required for elimination of the common algae, also the safe limit to prevent the killing of some of the common fish. Since there are several species of most of the algae mentioned, and the different species of a genus are not equally sensitive to copper sulphate, and since furthermore temperature, hardness of water, amount of organic matter present and other factors must be taken into account, these figures should be considered as suggestive or approximate and are not to be interpreted as a rule for general use wherever algae are found. Each lake or reservoir offers individual problems which require special study and special prescription, and no general rule can be formulated.

The figures represent the amount of copper sulphate, expressed in parts per million:

	Required to destroy algae.
Conferva	1.00
Cladophora	1.00
Hydrodictyon	0.10
Anabaena	0.10
Clathrocystis	0.10
Aphanizomenon	0.15-0.20
Microcystis	0.20
Fragilaria	0.25
Melosira	0.30
Stephanodiscus	4.00

	Safe limit for fish.
Trout	0.14
Carp	0.30
Sucker	0.30
Catfish	0.40
Pickerel	0.40
Goldfish	0.50
Perch	0.75
Sunfish	1.20
Black bass	2.10

It may be noted here that the amount required to destroy several of the common algae is greater than trout are able to endure. Fortunately trout prefer cool, swift-running water, conditions unfavorable for the growth of our most objectionable algae. The amount of copper sulphate required for destruction of Melosira is very close to the limit that can be endured by carp, suckers, catfish, and pickerel. Sunfish and black bass alone are able to endure the 1/1,000,000 solution necessary for destruction of Cladophora and Conferva. The complete elimination of Stephanodiscus by copper sulphate would require a solution which would destroy all of our common fish.

Results of Copper Sulphate Treatment.—As to the effectiveness of copper sulphate in destroying the objectionable algae, we can get no clearer idea than by examining a few curves showing the response of some of these algae to the chemical, where it was used in treating lakes under normal conditions. The accompanying diagrams are largely self explanatory, but it may be worth while to call attention to a few of the more interesting points which they illustrate. They represent the result of a study of several lakes, the curves being based upon microscopic counts of algae present in the water on the dates as indicated.

On account of the variation in size of the different species of algae, a greater uniformity has been obtained by expressing the number of algae in "standard units" instead of individuals, per cubic centimeter of water. The "standard unit" is a cube 20/1,000 of a millimeter on a side. In some species of algae, the individual may contain more than one standard unit, but in others as in Clathrocystis, for example, it may require more than 100 individuals to make a single standard unit.

The following table shows approximately the size and capacity of the various lakes observed:

Name of Lake.	Size in acres.	Maximum depth in feet.	Average depth in feet.	Capacity in gallons.
Amber	183	16.5	12.5	761,280,000
Hall	487	10.7	8.5	1,378,210,000
Budd	207	17.0	11.0	759,000,000
Sisseton	96	8.5	6.5	207,360,000
George	45	7.5	5.5	82,350,000
South Silver	200	24.0	16.0	1,062,000,000
Vadnais	358	57.0	27.0	3,240,000,000

The following table shows the number of pounds of copper sulphate used in the several lakes for treatments indicated in accompanying curves:

Name of Lake.	First. treatment.	Second treatment.	Third treatment.	Fourth treatment.	Fifth treatment.
Amber	720	1,000	1,000	1,030	.....
Hall	1,200	1,600	1,600	1,600	2,000
Budd	700	1,000	1,000	1,480	2,000
Sisseton	200	360	360	560	600
George	80	140	200	200	.....
South Silver	840	1,760	1,760	.....	.....
Vadnais	2,700	2,700	2,700	3,150	.....

Of these lakes, Amber, Hall, Budd, Sisseton, and George, form part of a chain at Fairmont, Martin County, Minnesota. They are situated near each other, being connected by short narrow channels. The water flows through the series in the order mentioned from Amber to George. South Silver Lake is also in Martin County and lies ten miles south of Fairmont. Vadnais Lake is situated in Ramsey County, eight miles north of St. Paul.

Experiences at Amber Lake.—In Amber Lake (Fig. 1) we note that two of the blue-green algae begin to develop early in May. On June 5th when the copper sulphate treatment was given, one of these, Clathrocystis, had reached 1,500, while the other, Aphanizomenon, had mounted up to 3,600 per cubic centimeter. Aside from these two the total of all other algae combined amounted to less than 100 per cubic centimeter. Six days after the treatment practically all algae had disappeared, the count at this time showing a total of but 15 per cubic centimeter as opposed to 5,180 on the day when the copper sulphate was applied. Another alga, Anabaena, made its appearance about this time but a treatment on June 24th eliminated it until September when it reappeared. Certain blue-green algae appeared in considerable numbers in July and made necessary a third treatment of July 24th. A sample taken on July 15th showed the water to be comparatively free from algae, and the next sample, taken on July 30th showed the water equally free from these organisms, but from reports as to the general appearance of water on July 24th when the copper sulphate was applied, it is estimated that not less than 3,000 standard units of these blue-green algae per cubic centimeter were present at this time. Clathrocystis appeared again about August 6th, and reached 1,300 per cubic centimeter on August 18th, but was completely destroyed by the treatment given at this time. Anabaena and Aphanizomenon appeared again in September, but on account of the lateness of the season were unable to make much progress and later with the lowering of the water temperature they disappeared.

Results at Hall and Budd Lakes.—Hall Lake was in much better condition on June 5th than was Amber Lake, though the algae occurring in the two lakes were of the same species. On account of the larger size of this lake, conditions are not so favorable for the scum-forming algae as in the other lakes of the chain. It is interesting to note that the alga most abundant in Hall Lake during the summer was Melosira, which is not a surface-dwelling form, but a subsurface species which was evenly distributed from the surface to the bottom of the lake. The treatment of July 16th checked the development of this organism and reduced the number slightly, but within two weeks it began another rapid increase. It may be said here that the amount of copper sulphate used at this time while adequate for destroying the scum-forming species was only half the strength required for the complete destruction of this more resistant form.

In Budd Lake the blue-green scums find conditions quite ideal for their development. By May 28th, Spirogyra, one of the bright green slimes, had reached 2,000, while Clathrocystis had increased to the number of 18,000 per cubic centimeter. Both of these forms are very sensitive to copper sulphate and remarkable results followed the treatment. Spirogyra did not appear again during the season, and Clathrocystis, after a second dose on June 25th was likewise eliminated for the rest of the year. Either of these species left unmolested would have continued increasing until September, and would have persisted in great numbers until October or November. Aphanizomenon and Anabaena, usually very abundant by July 1st, were delayed in their development until late in the summer and the treatment of August 30th cleaned them out for the remainder of the season.

In Sisseton as in Budd Lake, Clathrocystis developed a most luxuriant growth before the first treatment on May 28th, but was easily eliminated and caused no more trouble all summer. The treatment on June 26th was given not so much because of any apparent need for it in this particular lake, but because George and Budd, the lakes on either side and closely associated with Sisseton, were in bad condition and had to be treated at this time. It was felt that we might avoid contamination of these other lakes in the near future by cleaning them all up at the same time. So far as the blue-green surface scums were concerned the treatment had the desired effect, but it had no apparent effect upon the subsurface species, Melosira, which started a rapid increase shortly after the copper sulphate was applied.

In Lake George, as in the other lakes, Clathrocystis was one of the first algae to appear, but when once eliminated by the treatment on June 5th, it failed to establish itself again. Here, too, as in Sisseton and Budd Lakes, Spirogyra was completely eliminated by the first treatment and did not appear again. Aphanizomenon reached its highest point in this lake on June 25th, with 13,000 per cubic centimeter. Six days later not a single individual of this species could be found in the lake. While it reappeared later in the season it never became particularly abundant again. The treatment on July 16th here, as in the other lakes, was to eliminate Melosira, a sub-surface species.

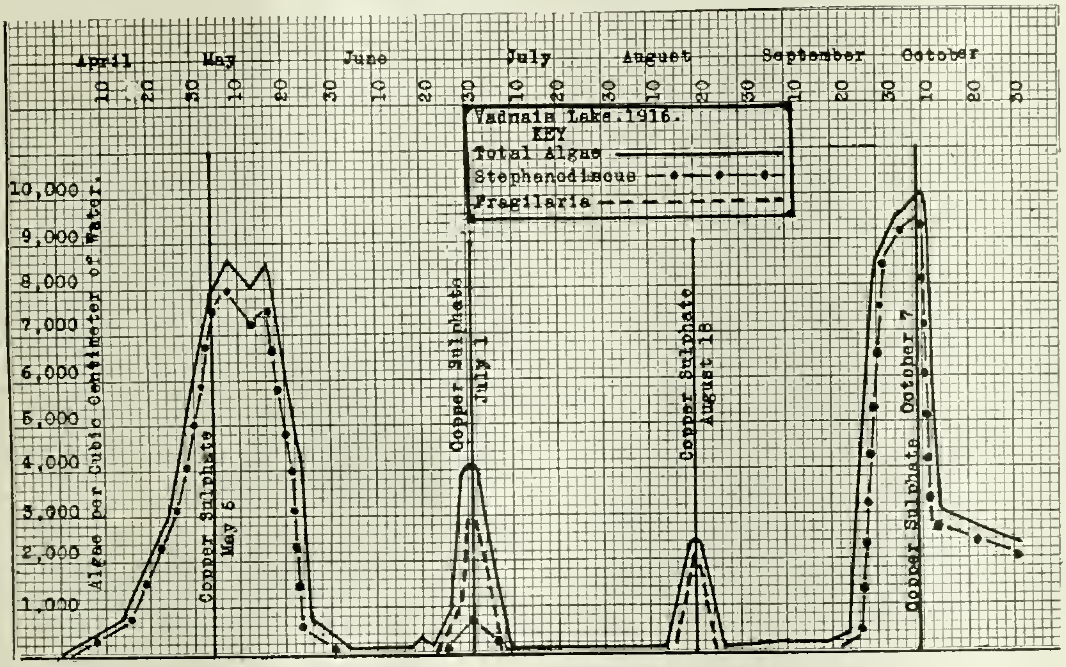


Fig. 3.—Effect of Copper Sulphate Upon Algae in Vadnais Lake.

Interesting Results Obtained at South Silver Lake.—South Silver Lake (Fig. 2) shows most interesting results. Here we find Stephanodiscus, a sub-surface species inhabiting deeper lakes and flourishing only in spring and autumn during the semi-annual overturn of the water. It disappears in May and reappears in September and was probably not here affected by the copper sulphate treatments of the summer. Fragilaria (F. crotonensis Kitton) - like Stephanodiscus, is characteristic of deeper lakes, but it flourishes during the summer and early autumn. Here its appearance was probably delayed a month or more by the treatments of June, and after the July treatment it slowly disappeared. The greater interest in South Silver Lake, however, lies in the quick response of the two scum-forming algae that appeared in May and June. Clathrocystis as in the Fairmont lakes was first to appear and had reached 14,000 per cubic centimeter when destroyed by the treatment of June 5th. It did not reappear. Anabaena had not started to germinate at the time of the treatment on June 5th and it therefore escaped all effects of this treatment. Six days after the treatment when Clathrocystis had practically disappeared, Anabaena was just beginning to germinate and there appeared 150 standard units of this alga per cubic centimeter of the sample collected at this time. Within a week's time the number had increased from 150 to 30,000 per cubic centimeter and the whole lake was literally green with this organism. The wind was blowing gently from the north and a sample taken near the central part ot a large bay on the south shore showed 80,000 of this alga per cubic centimeter. The copper sulphate needed for the treatment did not arrive for three days after this and no count was made on the day of treatment, but if the number continued to increase during the three days at the same rate as during the week preceding, the number at the time of treatment may have been as high as 250,000 or 300.000 per cubic centimeter. Four days after the treatment the number had dropped to 50 per cubic centimeter, and these were bleaching and apparently dead. A week later not a trace of them could be found. So green was the water on June 18th and so turbid that a white table plate disappeared completely from view at about ten inches below the surface. Four days after the treatment the bottom of the lake was visible ten feet beneath the surface. So thorough was the elimination of Anabaena at this time that it did not reappear during the entire season.

Results at a Deep Lake.—Vadnais Lake (Fig. 3) in Ramsey County, covers 358 acres and has a maximum depth of 57 feet. Conditions here are quite different from those of the Martin County Lakes. Copper sulphate was first used in this lake in 1915 and at that time the blue-green algae caused considerable trouble. Since that time they have been kept under control without difficulty. The forms that still persist, however, after several years of treatment with copper sulphate, are two sub-surface species, one of Stephanodiscus and one of Fragilaria. Fragilaria is easily kept under control for it is quite sensitive to copper sulphate and appears in summer when the water is warm and currents set up in the lake by winds seldom extend to a depth of more than 20 feet. The organic matter dissolved or suspended in the water at this time is comparatively small. The effect of copper sulphate upon this organism is well shown by the treatments of July 1st and August 18th.

Stephanodiscus, however, being much less susceptible to copper sulphate, and thriving in spring and fall when the overturning water is bringing up great quantities of organic matter, offers a much more difficult problem. As stated above, the amount of copper sulphate necessary to completely eliminate this organism would probably kill every fish in the lake, so that the best that can be done is merely to reduce its numbers when conditions are most favorable for its development. The treatment on Oct. 7th certainly shows that beneficial results may be obtained by using copper sulphate in quantities too small to bring about complete elimination of this organism. The number here was reduced from 9,400 to less than 3,000 in four days, and further reduction followed during the next ten days.

Precautions in Use of Copper Sulphate.—Having noted the effect of copper sulphate upon several algae as indicated in accompanying figures, there can be no question as to the effectiveness of this chemical in eliminating or controlling some of the most troublesome species of our lakes and streams. A study of lakes not treated shows that the scum-forming algae, such as Spirogyra, Clathrocystis, Anabaena, and Aphanizomenon, usually appear early in the summer and continue to increase in quantity until September or October. The application of copper sulphate will quickly eliminate these forms and if the treatment is given at the proper time and is thorough it may eliminate these forms for the remainder of the season. The control during succeeding seasons should be made much easier.

To those who contemplate the use of copper sulphate, one thing should be remembered. Copper sulphate is poisonous to fish and lower animals as well as to man, if used in too great quantities. The limit for treating to prevent the killing of fish is very close to that required for destruction of some of the troublesome algae. **Great care must be used.**

The work needs intelligent and constant supervision by one who understands the organisms in the lake. Microscopic examination is necessary to determine what organisms may be causing the trouble at any particular time and without this information there is sure to be waste of the chemical, to say nothing of the danger of killing fish and other animals.

With proper supervision the use of copper sulphate is absolutely safe; without such supervision it may be disastrous. In no case should this important work be left to the ordinary laborer.

The Balancing Reservoir of Baltimore Water Supply

A so-called balancing reservoir has been completed recently in connection with the Gunpowder River improvements to the water supply of Baltimore, Md. The reservoir was constructed as a means of limiting the pressure on the tunnel conducting water from the Gunpowder River to the city. This improvement was described by Wm. A. Megraw, Water Engineer of Baltimore, in a paper presented at the last annual convention of the American Waterworks Association, from which the following matter is taken:

Why the Balancing Reservoir Was Necessary.—The first Gunpowder works, which were completed in 1888, are composed of a low masonry dam across the river at Loch Raven—now known as the lower dam—Lake Montebello, a tunnel 12 ft. in diameter and 7 miles long from Loch Raven to Lake Montebello, and distributing mains from Lake Montebello to the city. The second Gunpowder works, which were completed in 1915, are composed of a low dam—now known as the upper dam—a filter plant, a pumping station to raise water from the tunnel to the filters, a filtered water reservoir and large distributing mains from the filtered water reservoir to the city. Upon completion of the filters, valves on the conduit leading to and from Lake Montebello were closed and the low service zone of the city took the greater pressure, due to the higher water surface in the filtered reservoir. With this new system of operation, the tunnel was subjected to an additional head of 17 ft. represented by the difference in elevation between the upper and lower dams. The third Gunpowder works were started in 1920, and, at the time of this convention, are nearing completion.

The upper dam now being increased from elevation 188 to elevation 240 above mean tide, will increase the storage from 1.5 billion gallons to 23 billion gallons. If the tunnel were strong enough to sustain the additional head, it would be possible to supply the filters by gravity for most of the time and resort to pumping only when the water surface in Loch Raven reservoir dropped considerably below the crest of the dam.

The tunnel is 12 ft. in diameter. For about 6 miles from the city end, it is deep below the ground surface in hard rock free of seams and is unlined. For the remainder of its length, about 6,000 ft., the tunnel is much shallower, passes through mica shist and seamy limestone and is lined with brick. Pressure tests were made on the tunnel by closing the gates at Loch Raven dam and allowing water to pass from the basins to the filter plant back into the tunnel. The tests proved that the head on the tunnel cannot be much increased without endangering its safety and causing excessive leakage. The tunnel might be strengthened by lining it with concrete, but it can be spared from service only four days at a time. It is estimated that three years would be required for lining it throughout, during which period of successive watering and unwatering, pressures throughout the low service zone in the city would change with every change of operation. Further, the city has been faced with a water famine with every dry year, so filling the large impounding reservoir as soon as possible takes precedence over all other water works consideration, and the city may not wait for a tunnel lining.

An outlet was provided in the new Loch Raven gate house for an additional tunnel, which should be built when the operating costs of the increasing pumpage equal the carrying charges on a new tunnel.

As the tunnel cannot be operated under much additional pressure, means of relieving the pressure to be imposed by the high dam had to be found. If the entrance of water through the tunnel could be exactly regulated, the head would not be increased, but the flow through the tunnel must vary from hour to hour with the fluctuating demands of the city and the gate openings at Loch Raven cannot be adjusted to follow immediately the change in demand. If a pump were thrown out of service or the electric plant momentarily failed, throwing all the pumps out of service, pressure would rapidly build up in the tunnel.

If water were passed from the tunnel directly into Lake Montebello, pressure on the tunnel would be relieved, but it would be necessary to discard the existing pumping station and install a new station on the shore of the lake to pump from the lake to the filters against a 50 per cent higher head than before.

It was recalled that water stood in an abandoned quarry, located approximately over the tunnel and about 4,300 ft. from Loch Raven, which was dry before the second Gunpowder works were built, and that the surface of this water rose when storm waters flowed over Loch Raven dam. The quarry occupied a natural depression in the hills, which might be converted into a reservoir by throwing a low dam across the hills and provide a water surface at elevation 200, which was predetermined as desirable. A water surface at elevation 200 will increase the head on the tunnel 8 ft. and its carrying capacity to as much as the impounded river is estimated to furnish, and will reduce the pumping head about one-fifth.

The function of a balancing reservoir is to supply the deficiency to the pumps when too little water is being admitted to the tunnel, and to absorb the excess when too much is being admitted.

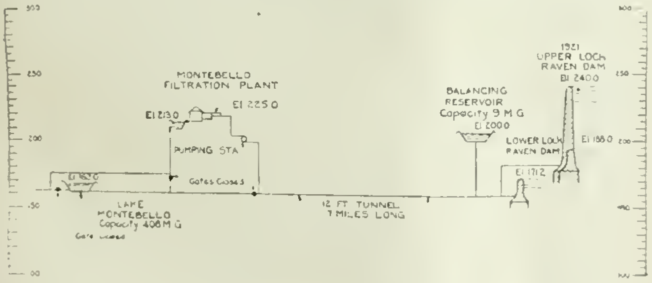
The cost of the balancing reservoir was estimated to be about one-tenth that of a new pumping station. Plans were prepared and a contract was awarded to Thomas Mullen of Baltimore on Sept. 10, 1921, for building the reservoir and appurtenances. All work was completed in April, 1922.

General Features of Balancing Reservoir.—The reservoir is irregular in outline. The bottom is a natural clay overlying rock. The dam forming the closure in the hills is of earth taken from the bottom and sides of the reservoir and rolled in 6-in. layers. The inside slope of the dam is 1 on 3 and the outside slope 1 on 2. The inside slope is lined with concrete slabs. The old quarry occupies one corner of the reservoir. A vertical shaft through soft rock provides communication between the tunnel and the reservoir. The shaft is 12 ft. in diameter and is lined with reinforced concrete. Six 36-in. diameter flanged openings are arranged radially around the shaft their inverts at elevation 190, which is the elevation of the reservoir bottom. The dam is at the opposite side from the shaft and as the original ground surface sloped away from the shaft toward the dam it was necessary to regrade a portion of the bottom, in order that the entire contents of the reservoir may empty through the shaft into the tunnel.

The greatest depth of water is 10 ft., so with small variation in head, the entire contents is available. The capacity is about nine million gallons.

A concrete lined channel 20 ft. wide at the bottom, having sloped sides, pierces the hillside beyond the dam to serve as a spillway.

The electric current feeding the pumping station is occasionaly interrupted, whereupon the pumps run backwards and a shock is produced by the contact between the water moving forward in the tunnel and the water moving backward from the filter plant. The contract provided a second shaft 12 ft. in diameter over the tunnel about 300 ft. from the Montebello pumping station, with the top open and at elevation 201, to provide overflow and relief for the shock of surging waters.


MONTEBELLO FILTRATION PLANT
El 225.0
El 213.0
PUMPING STA
Gates Closed
LAKE MONTEBELLO Capacity 406 M G
12 FT TUNNEL 7 MILES LONG
BALANCING RESERVOIR Capacity 9 M G
El 200.0
LOWER LOCH RAVEN DAM
El 171.2
El 188.0
1921 UPPER LOCH RAVEN DAM
El 240.0
250
200
150
100

Sketch Showing Balancing Reservoir in Relation to Parts of Waterworks Affected by Raising Loch Raven Dam.

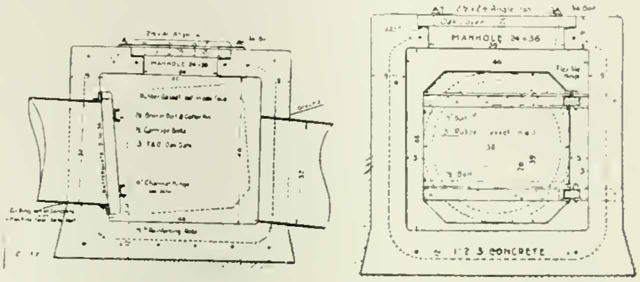
Entrance to the tunnel at Loch Raven is controlled by eleven 3 ft. 6 in. by 6 ft. sluice gates placed at three different elevations.

On April 11, 1922, the relief openings in the New Loch Raven dam were closed, allowing water to rise back of the dam. On May 6 the surface had risen to elevation 201 and gate regulation was then necessary to prevent water in the balancing reservoir wasting over the spillway. Gate regulations must continue until water overtops the Loch Raven dam, after which it probably will be desirable to set the gates, permitting a portion of the excess flow of the river to fall continuously over the spillway at the balancing reservoir, thus saving attendance and wear and tear of the gates. The height of water in the gate chamber back of the gates indicates the height of water in the balancing reservoir and a self-recording gage gives the gateman all the information he needs. A turbine pit was left in the gate chamber in which an hydro-electric unit may be placed, for mechanically operating the gates and for lighting the dam.

The cost of the reservoir and appurtenances was approximately $60,000.

Unusual Type of Valve for Dyking District Pumping Plant

An unusual feature of the discharge conduit of the new pumping plant installed recently for the Maple Ridge Dyking District, in British Columbia, is the use of a reflux valve. This is really a flap-valve swung from the side, but instead of being placed, as usual, at the outlet end of the discharge pipe, it is enclosed in a reinforced concrete chamber placed 18 ft. from and at the same level as the pump. This position was adopted in order to give greater accessibility to the valve, and to facilitate priming. The following details regarding the valve are taken from an article by H. M. Burwell in The Contract Record:



Details of Reflex-Valve.

The reflux-valves adopted eliminate the use of the usual gate valve, and will act automatically without any attention from the operator in charge of the plant. They have oak gates faced with inlaid rubber gaskets and provided with flexible hinges to adjust themselves to the gate seats, which are tooled cast-iron flanges rivetted to the steel discharge pipes.

The whole is enclosed in reinforced concrete chambers provided with man-holes of sufficient size to easily inspect or remove a gate and make repairs if ever found necessary. The chambers were made to be as nearly air-tight as possible, and the concrete actually adopted consists of a rich mixture of one sack of portland cement to 1½ cu. ft. of sand (1 fine to 2 coarse) and 2 cu. ft. of torpedo gravel.

At first when trying to prime the pumps it was found that the wide rubber gaskets on the valve doors did not give a proper contact (due to inequalities). These were taken off and grooves were cut into the faces of the oak doors, into which were inserted "Tucks" packing, 1 in. square, held in place by ¼ in. x 1 in. metal rings on each side, allowing the packing to project ¼ in. beyond the face of these rings. A cast iron weight of 130 lbs. was also bolted to the back of each door to facilitate its closure. These improvements have placed the valves in first class working order, so that as soon as a pump is stopped the door closes gently and is ready for the next priming.

American Association of Port Authorities to Meet at Toronto.—The 11th annual convention of the American Association of Port authorities will be held in Toronto, Canada, on Sept. 14th, 15th, and 16th. The convention will be followed by an excursion down the St. Lawrence River through the Thousand Islands to Montreal, where an opportunity will be given to see the terminal facilities of this port, after which the excursion will be continued down the river to Quebec, where the Harbor Commission will receive the members of the Association and their guests, and exhibit their harbor and its terminal facilities. Benjamin Thompson, Tampa, Fla., is president of the Association.

Problems in the Reforestation of Watersheds

Experiences of Scranton (Pa.) Water Co., Related in Paper Presented at Last Annual Convention of American Waterworks Association

By GEORGE R. TAYLOR,
Chemist and Bacteriologist, Scranton Gas & Water Co., Scranton, Pa.

There are numerous reasons why waterworks plants are particularly favorably situated for reforestation. They are frequently large owners of land which, naturally, has but few uses to which it can be put. They are interested in problems of the run-off from the catchment area, the peaks of flood and the depths of drouth, the turbidity of the streams, the sanitary quality of the water; all of which would be more or less favorably influenced were the watershed largely covered with forests.

Safety first, last and always is the one imperative necessity in forest work and is spelled fire protection. The reason why we have 5,000,000 acres in our great Pennsylvania desert is forest fire, that curse of the forest which has turned our former woodlands into barren, desolate tracts. The first step in combating the forest fire evil is an efficient state forest fire system, with district fire wardens covering the entire state. Each district should have its fire towers and watchmen and the district warden should have the authority and the money to secure men to fight forest fires. Such a statewide system is imperatively needed if forest fire damage is to be reduced to a minimum. Supplementing state effort there should be effective work done by the individual owner. Here in Pennsylvania the state department began a thorough statewide fight against forest fires in 1920. This year in our own district we have a district warden and 150 fire wardens to cover the 2,264 square miles in the Scranton district.

Scranton County's Experience in Fire Protection.—Our own experience in fire protection covers 20 years of work, during 18 years of which we were absolutely alone in our efforts, receiving no help from either the state or from private owners. This fact must be borne in mind, as it has had much to do with the thoroughness of our preparations and the costs of our fire fighting service.

We hold some 19,000 acres of land scattered over three counties in northeastern Pennsylvania. About 7,000 acres are in a solid tract 6 miles long and 2 wide adjoining the City of Scranton and in part within the city limits. This area is readily accessible from the city by various public roads and the 16 miles of our own macadam road which we maintain upon it. It is, in fact, a great public park through which on holidays and Sundays thousands of people pass. Because of these conditions fires are numerous and we are forced to maintain a constant vigilant watch.

In the center of the tract we have a large farm where we keep a force of some 20 men who are variously employed in farm work, road maintenance, sawmill and forest work, general watershed care and work on the city system. A watchman is kept on our fire tower and the men are always ready to drop their tools and rush to a reported fire. On Sundays and holidays they are kept in waiting, reinforced by an automobile truck to carry them rapidly over the territory.

The district is roughly bisected by a road running through the entire tract and is further cut up by our own road system. It is divided into smaller blocks by our fire and land lines, which total about 20 miles in length. The care of these fire lines, watching for fires, and fire fighting have meant an annual expenditure of about 60 ct. per acre for the entire tract. This is very high, but has been rendered necessary because of the extreme fire hazard which we have to face.

Even with all this care 400 acres have been burned over in the past 10 years or 6 per cent of the entire tract. In contrast to this we have 3,000 acres on the head of our main stream in a thinly settled region where our only expense is to fight an occasional fire which starts from the railroad. Or again a tract of about 1,000 acres in a thickly settled farming district where fires are practically unknown and nothing is spent on fire protection. We feel that the activity of the State Forestry Department will in the near future materially lessen these high costs as well as furnish more thorough protection.

Method of Fighting Fires.—In actual fire fighting our men are equipped with 4-gal. galvanized iron canteens for carrying water which are strapped to their backs, chemical extinguishers, iron rakes, pails, and so forth. Our main reliance is placed on beating the fire out by the use of water and evergreen boughs. It will be understood that we are speaking of surface fires in the low brush which grows on our mountains, not of big timber fires. We fall back on our fine lines for back firing as a last resort in case of high wind or rapid progress of the fire.

The maintenance of fire lines is a problem in itself. Probably a fire line should be looked upon merely as a line from which to back fire. From this standpoint it might be a line 2 ft. wide from which all top soil has been removed to make the line absolutely devoid of vegetation. On the other hand, a 20-ft. fire line is more satisfactory in many ways, and if a fire line is to be regarded as a line on which to hold a fire a 20-ft. line is more successful than the narrower line. In such a line the removal of the timber is followed by a growth of sprouts, weeds and brush which is more dangerous than the original stand. Mowing and burning every fall will keep the fire line in a fairly good shape, but is attended with some hazard and encourages the growth of weeds.

One method of removing this second growth is by grubbing the line with pick axes, removing the roots, smaller sprouts by the roots, and burning the line. This is expensive, as grubbing will cost from 30 to 40 ct. a square yard. Furthermore, it is not complete and repeated grubbings are necessary before the line becomes a barren waste.

Killing Vegetation on Fire Lines with Gas Tar.—We have experimented with chemicals in killing the vegetation on our fire lines. Most chemicals, however, as they are washed out of the soil by rain, seem to stimulate the growth of weeds. We have used gar tar on our fire lines with a considerable degree of success. Gas tar, a residue from our gas works, is a thin, sticky fluid, pours readily, is noninflammable at ordinary forest fire temperatures, is not readily washed out of the soil by rains, and is very toxic to vegetation. We have applied this by hand, using sprinkling pots. It requires 1 to 2 gal. per square yard of fire line to be effective in killing vegetation. Just how long the tar will last we cannot say, but our lines after two or three summers are holding in good shape.

We have not as yet put gas tar on a line where the only preparation had been to cut and burn the trees and bush. The quantity of tar would have to be increased, but we have no doubt but that the results would be equally good as the tar will kill sprouts of a year's growth. Gas tar is a by-product in water gas manufacture and can be sold for 5 ct. per gallon. This is of tar of not more than 3 per cent water content. The tar as we have generally used it, contains up to 25 per cent water which aids in pouring it, but decreases its toxic effect. We figure that it costs us from 10 to 15 ct. per square yard to apply gas tar so as to form an effective fire line.

Where coniferous timber is removed there is left in the top layers of soil sufficient seed to insure natural regeneration of the forest. With hard wood the same results are effected by sprouts from the roots. The first fire on this tract destroys the seed and sprouts, successive fires burn out the top soil, until finally we have the barren tracts so common in our Pennsylvania mountains where only fire cherry, birch and poplar grow. In such lands artificial regeneration is an absolute necessity. Further than that, if one wishes to control the type of tree growth, it can only be done by planting. Then natural regeneration on lands which have been scarred by fire, even if very slightly, is extremely slow.

Selection of Trees for Planting.—The species of trees which should be planted are, first of all, those which are native to your particular section. In addition experimental plantings should be made of various other trees which may seem desirable. Planting should not be confined to a single species any more than you should put all your eggs into one basket. Consideration should also be given to future utilization of the timber. A water system can make more use of the soft woods than of the hard woods. With us the prevailing types of trees are the hard woods, such as maple, oak, beech and birch, so there has been no necessity to plant them. In selecting a species for a given tract consideration must be given to the nature of the ground, swampy or dry, sheltered or exposed, whether open or covered with undergrowth, type of soil, and various other factors.

The following table will give the habitats of the principal softwoods of the eastern section:

Species.	Soil.	Shade.
White Pine, P. Strobus.	Moist to moderately dry	Very tolerant
Pitch Pine, P. Rigida	Direr soils	Will stand some shade
Red Pine, P. Resinosa	Moist to dry soil	Intolerant of shade
Norway Spruce, Picea Abies	Moist to swampy soil	Very tolerant
European Larch, Larixdecidea	Gravelly soils	Intolerant of shade
Scotch Pine, P. Sylvestris	Anything except swamp	Intolerant of shade
Austrian Pine, P. Laricio	Dry to moist soils	Intolerant of shade

If you are fortunate enough to have old fields available for planting you can put in almost any species you wish and get satisfactory results. If you are planting old fire burns covered with sweet fern, briers, tangles of scrub oak and groves of poplar, fire cherry and gray birch with an occasional cak or maple thrusting its green crown up above the tangle to belie its fire scarred trunk, you are practically limited to white pine on the drier tracts and either white pine or Norway spruce in the wetter locations.

We have been trying pitch pine, P. Rigida, in places of moderate shade, but have not had enough years of experience to determine how satisfactory it is going to be. White pine and Norway spruce are shade loving and will eventually find their way up through scrub oak and other low growing bushes.

The trees obtained for planting are seedlings from 1 to 3 years old and 4 to 10 in. in height. They may be bought from private nurseries, as were our earlier plantings. Of recent years the Pennsylvania Department of Forestry has furnished forest trees free to planters, making a charge to cover the cost of digging, packing and transportation. A number of other state forestry departments are doing the same thing and it is an activity which waterworks people should urge in all states.

Pennsylvania this year is sending out 4,000,000 seedlings, next year they expect 6,000,000, and in 1924 and therafter they expect to have 20,000,00. The trees are bunched in fifties, boxed and shipped by express. Immediately upon receipt they should be inspected and "heeled in" in the ground. To "heel in" a furrow about 4 in. deep should be plowed in good soil which is reasonably free from stone, The bunches should be put in this furrow and the dirt packed back about the roots covering the stems in part. The row should not be more than two bunches wide to avoid heating. If the ground is partially shaded so much the better. "Heeled in" in this way trees can be kept in perfect safety for two weeks during March and April.

How the Planting Is Done.—We plant the trees from 4 to 6 ft. apart, generally about 4 ft. The latter distance means 2,700 trees to the acre, while 6 ft. requires 1,200 trees per acre. We make the holes with broad-bladed picks known as mattocks. Following the pick men come the droppers carrying the trees in pails having a little water in them to keep the trees moist. One man will drop trees for two to three rows of pick men. Behind these come the men who actually plant the trees, one man to each row.

The planting is very simple. Just stick the tree in the hole and scrape the dirt back in with the hand, a scraper or, as some of our men seem to prefer, a small stone. This stone is then used to pack the dirt around the tree by striking the ground with it. Another way to firm the tree in is to step on the dirt that has been thrown back into the hole. This firming in process is very essential in tree planting.

The imperative precaution to be taken in handling seedlings is the same as that for transplanting all trees—do not let the roots dry out. Bunches must not be left around to be exposed to the sun or air and the work should be so handled that those covering the trees keep well up with those dropping them. To mark the planting line the outside line of holes should be left unplanted on each trip across the piece of land being planted. If the planting site is at a distance from the place where they are heeled in enough trees for the day's work should be brought up and heeled in at a convenient spot.

In old mowing land where the land if smooth it may be found advantageous to plow shallow furrows to facilitate planting, although we have always stuck to hand planting. Where the ground is favorable a force of men will put in 1,200 to 1,500 trees per man per day. In wild land covered with scrub oak and briers the average may drop to 500 trees a day. The cost of the trees in the ground including the department charges for digging, expressage, and our labor planting, total charges will run from $3 to $5 per 1,000 trees.

Trees should be planted as early in the spring as the ground is workable. Trees planted in March and early April do very much better than trees set in May as the earlier trees get rooted before the hot weather of July scorches them. Many failures are traceable to late planting and even where the trees survive they remain in a stunted condition for some years before making a start.

After planting little need be done for the trees except to keep out fires. In later years will come questions of thinning and utilization of the smaller trees in the tract which are being overgrown. These questions have not come up with us as yet.

One method of planting which has been tried in some instances is to plant the alternate rows to evergreens suitable for Christmas trees. In a few years these could be removed and sold thus giving an early income from the area. The feasability of this is debatable and we have never practised it. The mixed planting of trees has certain advantages over planting in pure stands. One important thing is that it tends to cut down damage due to disease.

Experiences at Scranton With Various Species of Trees.—We began our planting in 1912 putting out 80,000 White Pine. We continued planting pine at intervals until 1918 when we began experimental plantings of different species. We have now put in 985,000 trees of which 513,000 are White Pine. We have tried Scotch Pine, Red Pine, Pitch Pine, European Larch, Norway Spruce, White Ash, and Black Walnut. Our results have been somewhat varied in character. Some have been unqualified successes, other are as yet uncertain.

By far the greater part of our trees have lived although in some instances the growth has been very slow. Scotch Pine has not grown very rapidly with us, contrary to general experience. Our pitch pine plantings have been too recent to form any definite idea but as it is a local tree there is no reason why it should not succeed if the particular site is favorable. European Larch has been a complete failure with us both in growth and in withstanding our severe winters. One planting has only 5 per cent of the trees living; another under different soil and exposure conditions has 40 per cent living; while a third is somewhat between the two. Norway spruce has given us 90 per cent living but the seedlings do not grow. Some that were set out in 1918 have not grown more than 6 inches in that time. White Ash was a complete failure with us as was also the planting of Black Walnut nuts.

Red Pine has been a great success with us so far. Practically 100 per cent of the trees have lived and the growth has been very satisfactory. We find, however, that they are very intolerant of shade. In one field there is a large patch of sweet fern, covering nearly an acre. The red pine will not come up through this, either dying or standing still without making any growth. We plan to use Red and Pitch Pine in the near future wherever it is possible. Yet, because of scrub growth already existing, probably 90 per cent of our land either must be planted to White Pine or allowed to go through the slow and frequently unsatisfactory process of natural regeneration. Pitch Pine and Red Pine are moderately resistant to fire, owing to the large amount of pitch in the bark. Pitch Pine, in particular, will live through surface fires which kill all other trees.

Problems of Tree Diseases Becoming More and More Pressing Every Year.—We are only too familiar with the ravages of the chestnut blight and the resultant wiping out of the chestnut tree. The various scales attack some of our forest trees causing considerable damage. White ash is particularly affected by it and in our own section ash sprouts are being killed by scale to an alarming degree if you consider the relative scarcity of the trees and its high value for lumber. White Pine is attacked by the weevil, occasionally to such an extent as to practically destroy a plantation. The weevil is a white grub which bores the path of the leader, killing it. The tree is thus forced to make one of the lateral branches into a leader, in this way producing a crook. Usually the infection is not heavy enough to cause any more serious damage than this. The ravages of the gypsy and brown tail moths in New England are well known. All of those except the weevil were imported. The most serious importation of all is the white pine blister rust, which was brought into New England on imported white pine seedlings, some twenty years ago. The disease has spread slowly over the north until it is pretty well distributed over the white pine territory and threatens to wipe out the white pine tree as the chestnut blight has the chestnut.

White Pine blister rust is an infection of the inner bark of young branches of white pines, which infection slowly travels down the trunk and eventually kills the tree. The life cycle of the rust is in three stages, the first two stages of which are passed on white pine, while the third stage is passed on members of the ribes family, currant and gooseberries, either wild or cultivated. Its first stage on the pine is the dormant stage which lasts for from two to four years before passing into the second or active stage. In this stage the bark is killed in the center of the infection while toward the outer portion of the infection spores are produced. At the extreme edge mycelium threads extend the disease farther down the limb into the trunk bark. When the infection reaches the trunk the killing of the whole tree takes place rapidly. The spores produced in the active stage on the pine can only grow on leaves of members of the ribes family, i. e. currants and gooseberries, either wild or cultivated. In this third stage on ribes, spores are produced which will develop only on members of the 5 needled group of pines, the principal of which is white pine. Here it begins its life history over again.

It is thus evident that this rust will only develop and spread in those sections where both white pine and ribes are present. It is thus possible to grow either one of the two in a given district but not both. An infected white pine does not directly infect the white pine which stands beside it, but the spores must pass from the diseased tree to some currant bush. New spores must be formed, and these pass back to the sound pine tree. The spores which are formed on the pine tree are of high vitality and may be transmitted over long distances by the wind, animals, birds, moving vehicles and other agencies. The spores which are formed on the ribes plant are frail and of low vitality so they are carried only relatively short distances.

We are thus finding, rather unexpectedly perhaps, that currants and gooseberries are becoming infected over wide areas which were supposed to be free from the disease but that the infection of the white pines is taking place more slowly and over more limited areas. 100 to 600 yd. may be set as the limiting distances over which infection of the pines from diseased ribes may take place with 200 yd. representing the maximum, except extremely under favorable conditions.

It will be seen that we are not facing wholesale slaughter of the pines as was the case with the chestnut tree. The fact that the disease does not spread from tree to tree makes its progress slower and further more makes the possibility of its control much more certain.

Control of the white pine blister seem possible through extermination of all gooseberries and currants which are within 200 yd. of a given stand of white pines. At first thought this may seem prohibitive in its cost but work which has been done in New England and New York would indicate that on many tracts the costs are very reasonable.

We have not as yet done any work on removing ribes. We expect to send out inspection parties this summer to determine how numerous ribes are and to get some idea of the cost of digging them out.

You naturally ask why plant white pine at all under these conditions. There are several reasons why we should continue to plant white pine if there is any possible chance of success. First: There is no tree which produces timber of the quality of white pine. Second: White Pine will thrive under a greater variety of condition as to soil and moisture than most other trees. Third: No other soft wood except spruce can be planted in thick growths such as birch, poplar and scrub oak with any surety of the plantation growing up through the scrub. In our opinion there is no tree possessing the merits of white pine for general forest planting and we are loath to give it up without a struggle. As to substitutes there are no substitutes. Red Pine seems the most satisfactory one to try. It is hardy, a rapid grower, makes good lumber, is not subject to any known disease, but has the fatal defect for us, at any rate, that it can not be depended upon to come up through growth of underbush. Its use must be restricted to fairly open ground. In this respect it is similar to Scotch and Austrian pine and the larches. The spruces will endure shade but are not very satisfactory for planting in the drier soils.

Utilization of Dead and Dying Trees.—Three diseases have made more complicated the problems of natural regeneration as well as those of planting. They have also brought up the question of the utilization of the dead and dying trees in the already existing stands.

We are operating a small portable sawmill, utilizing first of all the dead chestnut and other timber and in addition taking out mature specimens of all trees for which we have use. We saw our own rough construction material together with such specialties as pipe blocks, stone boat plant, ties, wagon poles, fence posts and a variety of plank and timber.

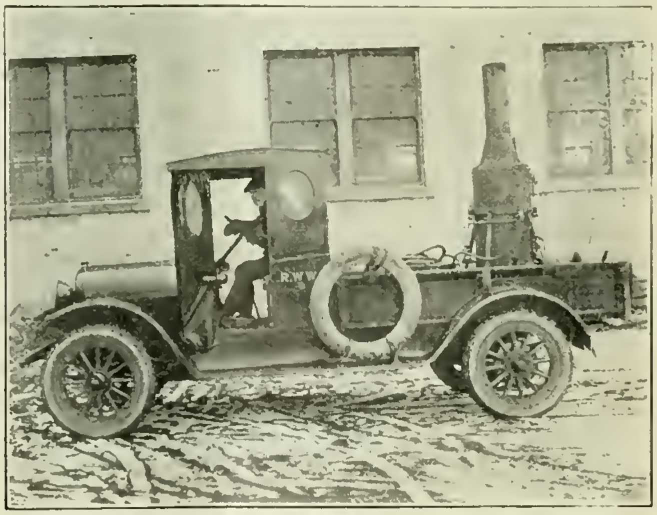
Much of this utilization work has been a direct result of the ravages of the chestnut tree blight. A considerable quantity has been sold as mine props, either on the stump or at the mine. Our own cuttings have been carried out in as careful a manner as possible, all brush has been burned and in many cases the small chestnuts sprouts have been removed to lessen the fire hazard and improve the general condition of the woods.

We are sawing about 75,000 board feet of lumber every winter and 10,000 to 15,000 pipe blocks. Fire wood, except high grade fire place wood, has no value in the anthracite region so everything below log size must be burned.

The cost of operation is necessarily high as we are picking the cut out of the general forest growth. However, we have been able to produce lumber at approximately local cost price when engaged on straight lumbering work. We feel that we have further done a valuable work by removing dead and dying timber which was rapidly becoming a serious fire menace. There is another factor to be considered here and that is the constant employment furnished the men. This is of great value in lessening seasonal unemployment.

Portable Boilers for Winter Work of Water Department

The equipment of the Maintenance and Repair Division of Rochester, N. Y., waterworks, includes a number of portable boilers, which have proved very useful in the winter seasons. The boilers are coal burners and carry about 60 lb. of steam.



Portable Boiler of Rochester, N. Y., Waterworks.

They are used in melting the snow and ice over gate box covers, in thawing out frozen hydrants and in other work. In freezing weather a boiler is sent to every fire to help the fire department loosen its hose from the frozen pavement and to thaw out hose connections and put the hydrant back again to a usable condition. Mr. Geo. E. Cripps, superintendent of the Division believes that for conditions of this sort one of these boilers will be more useful than a dozen men.

Trend of Prices in Waterworks Field

At the 1918, 1919 and 1920 conventions of the American Waterworks Association data* were submitted by Mr. Leonard Metcalf, Consulting Engineer, Boston, Mass., showing the effect upon the expenses and net revenues of waterworks of the higher costs and lesser efficiencies resulting from war conditions. In a paper presented at the recent annual convention of his association, Mr. Metcalf extends these data to include the records of the years 1920 and 1921, the figures being furnished, as in previous cases, by the managers of the plants covered by the report. An abstract of the paper follows:

Waterworks Now in Better Financial Condition.—The data submitted for the year 1920 and 1921 do not cover precisely the same plants, but they are practically the same to all intents and purposes. The records of about 45 plants, both publicly and privately owned, are included in the present tabulation, serving a gross population of 9,000,000 in the year 1920, as compared with about 50 plants, serving approximately the same total population, covered by the earlier reports.

The records indicate that, speaking in general terms, the waterworks of the country are past the period of acute distress due to the war, and that their revenues available for depreciation, interest, dividends and surplus, are approaching what would have constituted a normal basis under pre-war conditions, but they have not yet reached the higher level corresponding to post-war conditions, nor have they been permitted to make good the cumulative losses of the war period, nor has it been possible for them to make the deferred betterments to adequately meet the growing demands of the service. The results accomplished have been attained in part by increasing the rates charged customers, in part by natural growth, in part by increasing efficiency and decreasing cost of operation as the effects of the war have been gradually overcome, and in part by deferred maintenance and deferred betterments, and an undesirable reduction in margins of safety.

Cost of Unskilled Labor and Waterworks Material.—In Table 1 is shown a summary of data on changes in cost of unskilled labor and of materials used in the construction, maintenance and operation of waterworks from 1915 to 1921. The cost of contract labor, such as ordinarily used in construction, was of course much higher during the war period than that of the permanently employed labor used in maintenance and operation. It is to be borne in mind, too, that the maximum reduction in efficiency was probably at least 50 per cent at the peak or worst period.

Wages of Unskilled Labor.—The cost of unskilled labor reached its peak shortly after the presentation of the last report to the 1920 convention, the average cost for all works reporting, for the year 1920, being 50 ct. per hour, while the average cost in 1921 was 43.5 ct. per hour, and the present average rate is probably about 40 ct. The average price for 1920 represented an increase of 123 per cent over pre-war (1915) prices; the average for 1921, 94 per cent in excess of the 1915 prices—both without allowance for decline in efficiency or output.

The data, both as to prices and percentages, are shown in Fig. 1. It will be noted that the reduction, both in price and percentage, has been much less marked in the western group than in other sections of the country.

The increase in efficiency of labor has probably been somewhat more pronounced than the reduction in price—the efficiency or output has returned from 50 per cent below normal, to normal, broadly speaking.

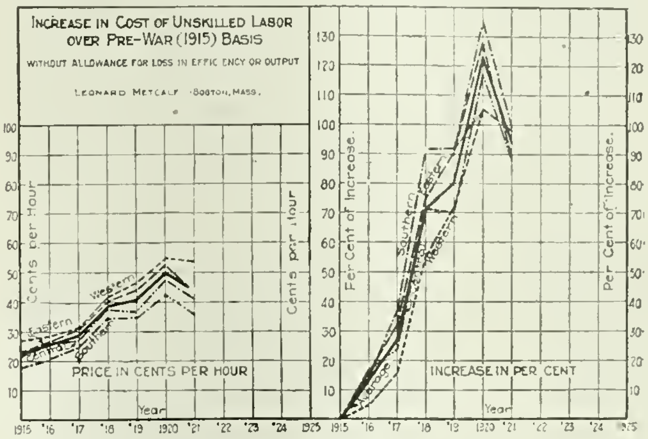


Fig. 1—Increase in Cost of Unskilled Labor Over Pre-War (1915) Basis.

Prices of Cast Iron Pipe.—When the last report was made to this association, two years ago, prices of cast iron pipe were practically three times normal pre-war prices. In 1920 they rose somewhat further. The average for 1921 was a little more than twice pre-war prices, and at the present time the price is probably a little less than twice that which prevailed before the war. It appears to be abnormally high still and out of line with pig iron and steel prices and with the price level of other manufactured products as well as of labor, seriously retarding the betterment of waterworks.

Valves and Hydrants.—The prices of valves and hydrants, which never reached so high a plane during the war as that of other materials, continued to rise in 1920 and receded in 1921 to a figure somewhat higher than that which pre-

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*See Engineering and Contracting, Aug. 14, 1918; July 9, 1919, and July 14, 1920.

TABLE 1—SUMMARY OF DATA ON INCREASE IN COST OF UNSKILLED LABOR AND WATERWORKS MATERIALS FROM PRE-WAR (1915) BASIS.

Item	Number of Records on Different Years	Prices Per Unit							(Pre-War Basis) Per Cent Increase Over 1915					
		1915	1916	1917	1918	1919	1920	1921	1916	1917	1918	1919	1920	1921
1. Unskilled labor in cents per hour														
(a) Eastern Group	15-18	23.0c	26.7c	30.4c	40.2c	43.8c	52.5c	43.4c	16	32	75	91	128	87
(b) Central Group	17-12	21.7c	25.3c	26.9c	37.2c	36.8c	47.1c	40.9c	17	24	71	70	117	88
(c) Southern Group	6-12	17.9c	20.6c	34.5c	34.3c	34.4c	42.1c	35.7c	15	37	92	92	135	99
(d) Western Group	7- 8	27.0c	28.5c	31.4c	41.8c	46.4c	54.7c	53.5c	5	16	55	72	105	98
(e) Average of Groups	.....	22.4c	25.3c	28.3c	38.4c	40.4c	50.0c	43.5c	13	27	71	80	123	94
2. Cast iron pipe per 2,000 pounds approximately	17-44	$24.23	$30.70	$51.60	$67.74	$69.20	*$76.53	$52.30	27	113	179	184	216	116
3. 6" valves	11-40	11.18	12.64	19.13	19.13	20.73	24.72	21.93	13	71	71	85	121	96
4. 12" valves	3-38	34.78	41.53	65.22	65.02	59.66	68.90	62.13	19	88	87	72	98	79
5. 2-way hydrants	6-38	26.69	32.04	43.13	51.80	47.16	52.30	47.10	20	62	94	77	96	77
6. Coal per 2,000 pounds														
(a) Eastern Group	13-15	$2.98	$3.80	$5.96	$6.00	$5.41	$7.34	$5.81	27	100	101	82	146	95
(b) Central Group	8-12	2.41	2.77	3.75	4.53	4.55	5.84	5.69	15	56	88	89	142	136
(c) Southern Group	7-12	1.92	2.01	3.03	3.89	3.78	5.35	4.45	5	58	102	97	179	132
(d) Western Group†	5- 4	3.97	4.37	6.31	7.92	4.70	5.60	5.29	10	59	99	18†	41	33
(e) Average of Groups	.....	$2.82	$3.24	$4.77	$5.57	$4.61	$6.22	$5.43	15	69	97	63	121	92
7. Fuel oil in cents per gallon, South	1- 3	1.80c	1.80c	2.00c	4.28c	.....	2.35	2.93	0	11	138	..	30	62
Fuel oil in cents per gallon, West	1- 4	1.38c	1.50c	2.57c	4.05c	4.09c	4.16	4.16	9	86	193	197	201	201
8. Alum, per pound														
(a) Eastern Group	.....	1.12c	1.72c	1.48c	1.45c	1.66c	1.90	1.75	54	33	29	48	69	57
(b) Central Group	.....	0.91c	0.91c	1.25c	1.50c	1.40c	2.66	1.86	0	37	65	54	192	104
(c) Southern Group	.....	1.08c	1.38c	1.48c	1.78c	1.56c	2.17	1.81	28	37	65	44	101	67
(d) Western Group	.....	1.14c	1.21c	1.51c	1.53c	1.79c	2.04	2.23	6	32	34	57	79	96
(e) Average of Groups	.....	1.06c	1.30c	1.43c	1.56c	1.60c	2.21	1.84	22	35	47	51	108	73

*Range $50.60 to $83.50 per ton. †Small number makes record of doubtful value.

TABLE II—INCREASE IN REVENUES AND EXPENSES OF WATERWORKS IN THE UNITED STATES OVER THOSE OF 1915—IN PERCENTAGE.

Year	1916.	1917.	1918.	1919.	1920.	1921.	
Gross Annual Revenue—							
(a) Eastern Group....	10.1	12.8	20.6	23.3	37.4	44.6	
(b) Central Group....	9.1	11.4	26.4	23.3	53.1	68.9	
(c) Southern Group...	7.5	20.3	26.3	26.3	45.9	57.5	
(d) Western Group...	7.3	9.5	17.5	25.0	35.6	51.5	
Average	8.5%	13.5%	22.7%	24.5%	42.3%	53.9%	
Operating Expenses and Taxes—							
(a) Eastern Group...	21.9	41.1	49.7	47.1	91.3	95.3	
(b) Central Group....	9.3	37.3	62.3	63.1	129.0	143.9	
(c) Southern Group...	9.7	34.6	65.9	71.5	112.6	104.3	
(d) Western Group...	9.9	17.4	28.0	36.1	57.7	70.8	
Average	12.7%	32.6%	51.5%	54.4%	98.1%	102.9%	
Net Operating Revenues Applicable to Depreciation, Interest, Dividends and Surplus—							
(a) Eastern Group...	3.0	9.6	5.8	14.5	6.3	16.6	
(b) Central Group....	10.0	1.5	6.5	9.3	16.0	49.3	
(c) Southern Group..	3.7	4.0	10.9	12.0	8.5	9.3	
(d) Western Group...	4.3	5.3	14.4	22.1	29.6	42.3	
Average (actual).	3.4%	0.4%	4.0%	8.5%	9.7%	25.9%	
	1916.	1917.	1918.	1919.	1920.	1921.	1922.
Normal if 4 per cent, compounded annually.	4.0%	8.2%	12.5%	16.9%	21.7%	26.5%	31.6%
Normal if 5 per cent, compounded annually.	5.0%	10.3%	15.8%	21.6%	27.6%	34.0%	40.7%

vailed in 1919. The fluctuations were much less marked than in the case of cast iron pipe.

Revenue and Operating Expenses.—The fluctuation in gross annual revenue, operating expenses, including taxes, and in net revenues applicable to depreciation, interest, dividends and surplus, expressed in percentage over pre-war conditions, as exemplified by those of the year 1915, are shown in Table II and Fig. 2, in average amounts and for geographical groups.

It is to be noted that gross revenues, which lagged behind in normal rates of growth from 1915 to and including the year 1919, have grown more rapidly during the years 1920 and 1921.

Operating expenses, which continued to increase rapidly up to and through 1920, have increased very much less in 1921. Indeed, in the case of the southern group there has been an actual decrease in the operating expenses of 1921 as compared with 1920, and in many works there has been a decrease in per capita cost of operation.

The net revenue increased at a very slow rate to and including the year 1920. It has improved very materially in the year 1921. The average percentage increase for all groups has recovered to a point but little below the line of increase normal for pre-war conditions assumed in 1918 and carried forward as a straight line since that time, as shown in Fig. 2, though it is far below the plane of present price levels.

In the paper presented in 1919, the statement was made that "the net revenue of water works usually increases at the rate of from 4 to 5 per cent compounded annually." The straight line in Fig. 2, marked "Normal Increase," corresponds to an increase of 3.9 per cent annually without compounding and is, therefore, somewhat below the position which it would have had if the annual increments had been compounded, but the difference is not great and it is interesting to compare the actual conditions developed, with the forecast then made. These differences are shown on the three last lines at the end of Table II.

Increase in Net Operating Revenue.—A study of Fig. 2 and of the last three lines of Table II, indicate the following comparison:

PERCENTAGE INCREASE OVER PRE-WAR AMOUNT (IN 1915) OF NET OPERATING REVENUES, APPLICABLE TO DEPRECIATION, INTEREST, DIVIDENDS AND SURPLUS, COVERING 6-YEAR PERIOD FROM 1916 TO 1921, INCLUSIVE.

Actual.	Total in 6 years. Per cent.	Average per year. Per cent.
Normal	51 1	8.5
Normal compounded annual at 4%	89.8	15.0
Ditto at 5%........................	114.3	19.0

Expressed in words, this indicates that,

First, the actual growth in net revenue during the six year period from 1916 to 1921 inclusive, has been about one-half of the normal for the growth in population and service during this period under pre-war price and fair return conditions, despite the effect of such increase in rates as was actually granted in many parts.

Second, the present average net return is slightly below normal pre-war basis.

Third, the cumulative losses to the water works of this country, both publicly and privately owned, of this six year period (1916-1921), have not been amortized, nor can they be on the present rate basis within a reasonable length of time.

Fourth, while many works have been granted increases in rate which will probably enable them to maintain credit and to make much needed betterments and extensions of plant and service, this is not yet true of the average plants, therefore, many yet remain, the rates of which will have to be still further increased, if desirable standards of service are to be maintained.

Rate Increases Justified.—Assuming that the "normal increase" line in the net revenue diagram of Fig. 2 does represent the increase in net revenue which might normally have been expected under pre-war conditions (though as has been shown, it is really below a normal rate of increase) it is interesting to estimate approximately the extent to which the water works of the country have suffered from the failure to earn the revenue which should normally have accrued to them under pre-war conditions. Applying the differences between the assumed normal increase and the actual gain in net revenues for the various districts into which the country has been divided, and making approximate computations, it appears that the works represented by these reports have suffered a loss of upwards of $6,000,000 by the failure to earn the net revenues which might normally have been expected, during the years 1917 to 1921 inclusive. If the same ratio were assumed to hold for the entire country, with some allowance for the small proportion of the population not served by waterworks, it seems probable that the total loss to the waterworks of the country has approximated $50,000,000 on pre-war normal basis.

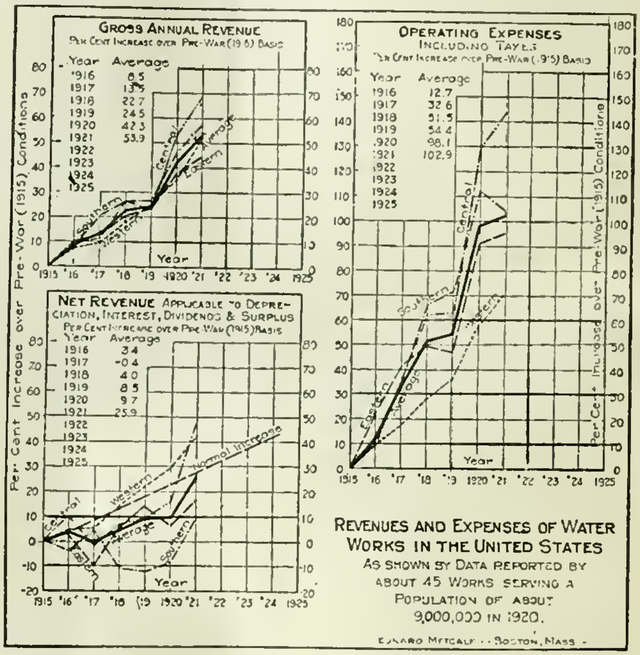


Fig. 2—Revenues and Expenses of Waterworks in United States as Shown by Data From About 45 Works Serving 9,000,000 People in 1920.

If proper recognition be given to the higher plane of war and post-war conditions, the amount below a fair return would probably be from four to six times as great, or say roughly, $250,000,000. Or to express the matter in a different way, the waterworks of this country are on the average back again on the deflated pre-war income basis, though they are still carrying the losses accumulated during the war, whereas the general loss in purchasing power of money or increase in costs would probably justify an average increase in net revenue over pre-war basis of at least 30 per cent and probably as great as 40 per cent or even more in some cases.

These later studies indicate the soundness of the earlier conclusion that the regulatory authorities have found it impossible under war conditions, at least, to remove the hazard of investment and burden of loss in such enterprises, and that the rate increases granted were not only inadequate but lagged after the adverse conditions by at least 18 months.

Previous Rate Increases Inadequate.—The financial problem involved is not yet solved. It is a difficult thing, practically, to increase rates now, where no increase or inadequate increase was granted during the war period—in the face of lower and yet declining prices. But such increase is essential in many if not most cases, if desirable standards of service are to be maintained. The public wants, is entitled to have, and is ready to pay for, a really high standard of service. The difference in cost to the family, between the good and the mediocre or inadequate service, is probably considerably less than is spent by many a family in chewing gum. Water service is by far the cheapest of all public services and easily within the resources of the public.

The public and the individual has a right to demand that the water service shall be good in every respect and that fair margins of safety shall be maintained. The administrators and regulators of waterworks have no right to carry the hazards and take the chances incident to a water supply which is inadequate, either in quality, or quantity, or in pressure.

The war is past and sound economic doctrine demands that the waterworks should be rehabilitated first of all, as they are the utilities most important to the public health and they involve the least cost to the public.

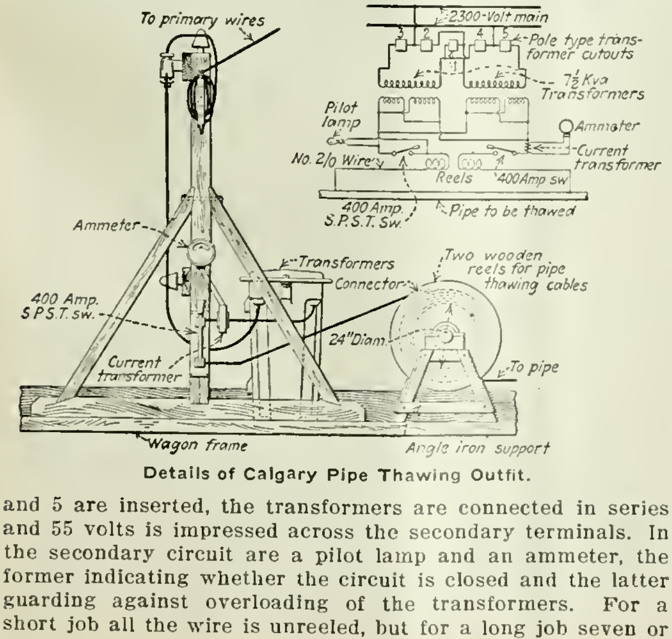
It is encouraging to note that, despite the difficulties involved, some of the utilities commissions are coming to sense the inherent dangers of the situation and the desirability of somewhat more liberal standards than those of the past. Already several have considered means of amortising losses of the war period, recognizing that failure to do so must have the inevitable effect of retarding recovery.

It is with the waterworks as with the individual. To deny good food and living conditions and normal hope of recovery to the patient recuperating from a long and serious illness, is but to court death or further continued burden; whereas a friendly attitude and atmosphere of encouragement, with occasional assistance from a competent doctor, on the other hand, hastens recovery and lightens the burden of all.

Portable Pipe-Thawing Apparatus of Calgary

By winding the two secondary leads of an electric pipe-thawing outfit in opposite directions on reels having a common steel shaft it is possible to obtain an adjustable reactance for limiting the current employed. Portable apparatus involving this feature has been used very successfully by the electric department of the city of Calgary, Alberta, Canada, states the Electrical World, which describes the arrangement as follows:

"The outfit consists essentially of a wooden frame for supporting the leads attached to the electric service circuit, two 7½-kw. transformers and two reels having a steel shaft. The details of construction are indicated by the accompanying illustration, which also shows the electrical connections. Five 2,300-volt pole-type cutouts are attached to the top arm of the frame. When plugs 2, 3, 4 and 5 are inserted, the primaries of the transformers are connected in parallel and 110 volts is impressed across the secondary terminals. If plugs 1, 3 and 5 are inserted, the transformers are connected in series and 55 volts is impressed across the secondary terminals. In the secondary circuit are a pilot lamp and an ammeter, the former indicating whether the circuit is closed and the latter guarding against overloading of the transformers. For a short job all the wire is unreeled, but for a long job seven or eight turns are left on the reels to limit the current."



Details of Calgary Pipe Thawing Outfit.

A Simple Method of Chlorine Dose Control at Waterworks

A simplified method of chlorine dose control, adaptable to use by those without training in chemistry, was described by Linn H. Enslow, of the Division of Engineering of the Virginia State Department of Health, in a paper presented at the annual convention of the American Waterworks Association. An abstract of the paper follows:

The proper and efficient control of chlorination of water supplies is exceedingly simple. No test for the chlorine "absorption factor" need be made unless this is desired as a matter of interest for a study of characteristics of a particular water. It is no longer necessary to know the rate-of-flow of the water being treated nor the rate-of-discharge of chlorine gas. Where the method of control is employed efficiently it no longer becomes a necessity to know the strength of hypochlorite of lime or of its solution where this is employed. The only condition essential to the success of the control test is that the individual making it be not color blind and that he exhibit a willingness to make the test as often during the day as necessary. Chlorine control by the test described below is practiced in 28 plants in Virginia. In 16 of these neither the superintendent nor the operators have had any training whatever in chemistry. The simplicity of the test appeals to all who have seen it made.

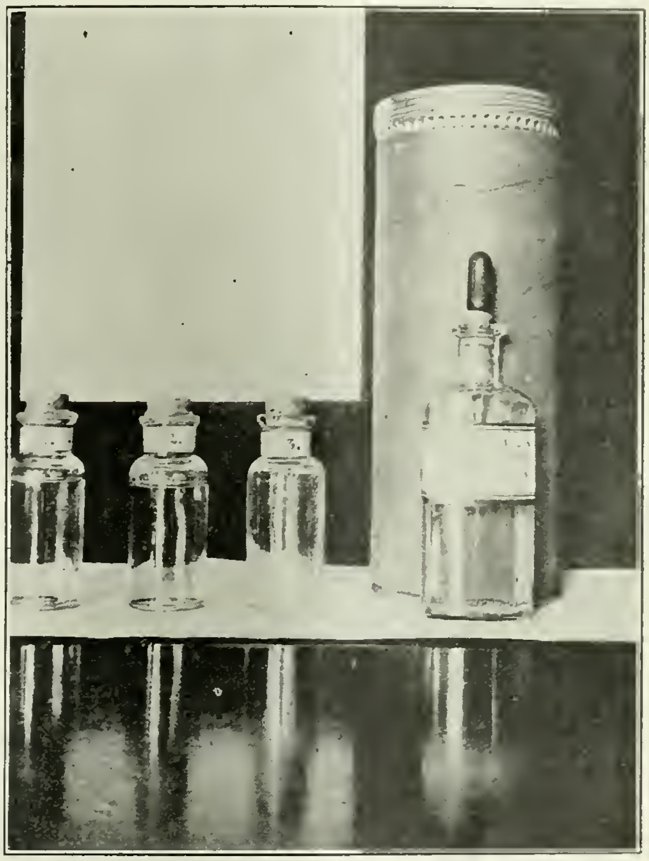


Fig. 1.—The Testing Outfit.

Equipment and Directions for Use.—Having carefully considered all tests at present applicable to the estimation of free chlorine present in small quantities in water it was decided to make use of the well known ortho-tolidine test given in the Standard Methods of the American Public Health Association.

The laboratory of the Division of Engineering of the Virginia State Department of Health keeps on hand standard color solutions prepared from potassium bichromate and copper sulphate and also ortho-tolidine solution. There are only two stock color solutions kept. No. 1 is prepared to represent the color produced by 0.1 p. p. m. and No. 2 to represent color produced by 0.2 p. p. m. free chlorine, when ortho-tolidine solution is added to a water sample containing these quantities of chlorine. As often as necessary small bottles (about 50 c. c. capacity) are filled with the standard color solutions and an 8 ounce bottle equipped with a stopper holding an eye-dropper is filled with the ortho-tolidine solution. These, together with a third empty bottle of the same size and tint of glass as the two holding the color standards constitute the "outfit" which is packed in a mailing carton for shipment to any plant where this is needed. The third bottle is intended for the water sample collected for the test which is to indicate whether the chlorine dose is or is not correct.

The "outfit" complete is shown in Fig. 1, the instructions being in the background. Where possible we prefer to have someone thoroughly familiar with the test show the operators the exact details. The mere fact that it is a chemical test will frighten some and it is highly desirable therefore, in order to avoid the likelihood of the test not being used, to demonstrate its simplicity first and give the detailed instructions later.

Test for Free Chlorine in Chlorinated Waters.

Apparatus:

1 Empty bottle for collecting sample for comparison with standards.
1 Bottle of ortho-tolidine solution.
1 Dropping stopper or eye dropper (to be used with bottle).
2 Standard color solutions representing .1 parts and .2 parts of chlorine.
1 Blue-glass nitrogen electric lamp for night testing.

Sampling Point:

A tap on the system not more than 25 nor less than 5 feet beyond the point at which the chlorine enters the water. (Note: Size of tap is of no importance but a long threaded nipple extending into the pipe to a point near the center of the pipe will produce a more reliable sample than otherwise is obtained).

Procedure.

(1) Open valve on tap and allow water to waste for a few seconds. Collect a pint or more of sample slowly in a clean glass jar or bottle. Whirl the water in the glass container to obtain a thorough mixing for a second or two.

(2) With the aid of the dropping stopper or dropper, add 5 drops of the ortho-tolidine solution to the empty sample bottle (No. 3).

(3) Fill the bottle with the water sample collected in the jar, but do not overflow it.

(4) Allow the bottle containing the chemical and water mixture to stand about five minutes in warm weather or ten minutes in cold weather. (Note: The time required to allow the mixture to stand is for a two-fold purpose. The first is in order that the reaction of the free chlorine on matter contained in the water treated may take place. The second is to allow time for the free chlorine remaining after the chemical reaction to combine with the chemical added to produce the color reaction.)

(5) After standing the required time compare the color produced in the sample (No. 3) with the two standards No. 1 and No. 2. The color should be darker than No. 1 but not darker than No. 2. If lighter than No. 1 the chlorine dose is too low and should be increased. If darker than No. 2 the dose should be decreased. (Note: At night it is necessary to compare colors under a pure white or a blue-white light.)

(6) In case a test shows that a change of dose in either direction is necessary, first change the dose and then wait about 10 minutes after the change before making a new test to see if the dose is correct. This time is required to allow the new chlorine dose to become constant at the sample tap.

The Importance of Test.

The test should be made at least every eight hours during constant rate of pumping or as often as the rate of pumping is changed.

The most important times at which to make the test at plants treating water that has not been filtered are three.

(a) After rains or other disturbances that cause the water to become muddy or even slightly turbid. At such times the chlorine dose should be raised to almost double before making test. Should the test then indicate too heavy a dose cut it down to a proper one. (Note: The presence of a small quantity of mud in the water will cause the color to appear darker than it really is. At such a time color in excess of No. 2 should be obtained as indication of an effective dose.)

(b) If the water becomes considerably muddy the test is valueless. In such cases apply chlorine until the sample drawn has a distinct odor of chlorine after standing the required length of time and then shaken.

(c) When the water shows signs of clearing up after the stream has "run down," the chlorine dose can be reduced by degrees and tests made to show whether the dose is correct.

A Few Facts Concerning Chlorine Control.—As stated above, where high turbidity is encountered the test for residual chlorine is useless. Here the "nasal-control" must be used. Even then as will later be shown the effectiveness of chlorination falls down under certain conditions.

Certain spring waters of low organic content and high bicarbonate of lime content will not stand a residual free chlorine content of slightly more than 0.1 p. p. m. without producing a slight odor of hypochlorous acid at the cold water taps and considerable odor at the hot water taps. Certain other waters have been treated to allow about 0.3 p. p. m. free chlorine to remain after 10 minutes and without any detectable odors or tastes resulting. The general average of waters in Virginia, however, will not safely stand more than 0.2 p. p. m. residual without danger of odors occurring at the service taps. We have, therefore, selected the most satisfactory range as that between 0.1 and 0.2 p. p. m. It might be added here that this same "outfit" and control modified is being used for chlorination control of swimming pools and sewage disposal plants.

It is gratifying to note that with but one or two exceptions all of the 28 plants, where chlorine in one form or another is being used, the B. Coli content has remained constantly absent in 50 c. c. quantities since the adoption of dose control through use of the test.

The test in addition to being used by operators is also used by city managers, superintendents and others on tap samples in their office as a matter of checking plant operation, provided the tap supplies water which received treatment not more than 8 hours prior to sampling.

The Slide Rule for the Power Plant Engineer

Ten years ago the average practical man turned up his nose at the "guess stick," as it was derisively called. This was mainly due to the following causes: Natural suspicion of anything unfamiliar; the frequent association (particularly in the case of young technical graduates) of slide-rule skill with ignorance along practical lines; bad blunders made by careless users of slide rules; the "inaccuracy" of the slide rule. Since that time the number of practical men who make daily use of the slide rule has greatly increased, but some of the old prejudice still lingers.

The chief remaining objection to the use of the slide rule is that it is "not accurate." This is true in precisely the same way that an ordinary six-foot rule is not accurate. When a distance is measured with such a rule is read as 5 ft., 4¾ in., the exact distance might very well differ from this by 1/64 in. without reflection on the maker of the rule or on its user. For most purposes this degree of accuracy is entirely sufficient, yet no mechanic would try to use a sixfoot rule in turning a pin to the proper diameter for a drive fit. He would use a micrometer instead. It all comes down to the old admonition, "Know your tools."

When using the long scale of a ten-inch slide rule for multiplication or division, the thing to remember is that one cannot expect to read closer than about one part in a thousand. If the exact answer is 1,012.2, a competent operator may read 1,011, 1,012 or 1,013. He will not ordinarily go beyond these limits. If the exact answer is 0.4016, the slide-rule answer should come between 0.4010 and 0.4020. For each problem that arises, only a certain degree of accuracy is required, and it takes but a moment to see whether this lies within slide-rule limits. Ninety per cent of the time it does. In fact the original measurements in most power-plant problems are out by more than one part in a thousand. In such cases the apparent absolute exactness of "long hand" arithmetic is nothing but an illusion.

The power-plant engineer who is skilled in the use of the slide rule and thoroughly acquainted with its limitations, can save a lot of time without sacrificing any necessary accuracy.—Editorial in Power.

Rating Curves for Canal Head Gates*

By JULIAN HINDS,

A great many attempts have been made to "rate" canal gate structures of the type shown in Fig. 1, usually without success. A more or less general impression now prevails that these outlets cannot be rated. A rating curve for such a structure would in a great many cases be of value even though it might be lacking in extreme accuracy. Approximate measurements of quantities are often required at points where the installation of an accurate measuring device is not warranted.

Observations have generally been directed toward finding a coefficient, which we will here call C', for use in the formula,

$$V_1 = C' \sqrt{2gh_2} \tag{1}$$

where V_1 is the mean velocity through the gate opening. It can be shown theoretically that C' cannot be a constant. The discharge through the orifice is not produced by the apparent head h_2, but by some larger head h_1 which obtains immediately below the gate. The relation of h_1 to h_2 depends upon the velocity head recovered between A and B, Fig. 1. If h_2 is measured just inside the barrel, or against the head wall just outside, the corresponding mean velocity may be taken as the discharge divided by the area of the barrel, provided, of course, that the tube is running full. If the gate is wide open the velocities at A and B will be the same, and h_1 will be equal to h_2. If the gate is, say, three-quarters closed, the velocity at A will be four times as great as at B, the corresponding velocity heads having a ratio of 16 to 1. If the gate is half closed the velocity head at A will be four times that at B; and so on for other percentages of gate opening. As in any other type of transition a part of the reduction in velocity head between A and B will be recovered and will be manifested as pressure head at B. This recovery added to h_2 will give h_1.

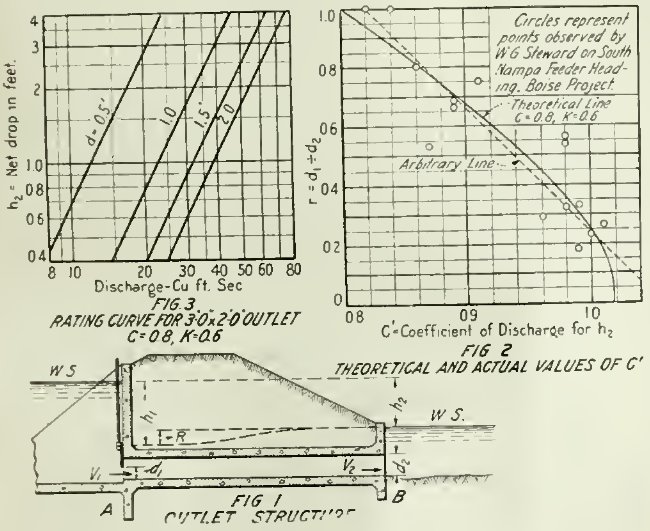


FIG. 3
RATING CURVE FOR 3'-0"×2'-0" OUTLET
C = 0.8, K = 0.6

FIG 2
THEORETICAL AND ACTUAL VALUES OF C'

FIG 1
OUTLET STRUCTURE

Figs. 1 to 3.—Typical Turnout and Rating Curve.

The relation between h_1 and the mean velocity through the gate is determined from the usual orifice formula—

$$V_1 = \sqrt{2gh_1} \tag{2}$$

where C is an experimental constant depending upon the details of the orifice. The recovery of head may be assumed to be

$$R = \frac{K}{2g}(V_1^2 - V_2^2) \tag{3}$$

K being a factor giving the proportion of recovery possible under the given conditions.

It is desired to find V_1 in terms of C, K, and h_2. It will be necessary to introduce a fourth factor to represent the ratio of V_1 to V_2. Where the gate and the tube are of the same width this ratio, which we may designate by r for convenience, is equal to d_1 divided by d_2, and we may write

$$V_2 = \frac{d_1}{d_2} V_1 = rV_1 \tag{4}$$

Inserting this value for V_2 in equation (3) gives—

$$R = \frac{K}{2g} V_1^2 (1 - r^2)$$
$$= KC^2h_1 (1 - r^2) \tag{5}$$

Therefore, since

$$h_1 = h_2 + R$$

we may write

$$h_1 = h_2 + KC^2h_1 (1 - r^2)$$

whence

$$h_1 = \frac{h_2}{1 - KC^2 (1 - r^2)} \tag{6}$$

Placing this value of h_1 in equation (2) gives—

$$V_1 = C \sqrt{\frac{2gh_2}{1 - KC^2 (1 - r^2)}} \tag{7}$$

The co-efficient C' in equation (1) may therefore be expressed thus:

$$C' = \frac{C}{\sqrt{1 - KC^2 (1 - r^2)}} \tag{8}$$

For high values of C and K, C' may readily exceed unity for small gate openings. With the gate fully open C' = C.

The relation of C' to r for C = 0.8 and K = 0.6 is shown in Fig. 2. A number of observations made by Assistant Engineer W. G. Steward for a turnout on the Boise Project are also platted on this diagram. It will be noted that the observed points follow, in a general way, the theoretical line. Additional ratings are to be made for this same outlet in the hope that a definite curve for C' can be found. If C and K are constants the final line should follow the general form of the theoretical curve shown in Fig. 20. It may be found, however, that these functions are variable, and that some arbitrary straight or curved line best represents the variation in C'.

After a curve for C' is found a rating diagram can be constructed similar to Fig. 3. If logarithmic co-ordinates are used all lines will be straight, but plain co-ordinates may be used if desired. Curves for d_1 may be platted for each 0.10 ft., or at closer intervals if required. It may be found convenient in rating a given outlet to use d_1 rather than r as an argument in Fig. 2.

If there is any considerable velocity of approach the corresponding velocity head should be added to h_2. If the barrel is long the friction may affect the apparent values of C and K, but should not interfere with the rating of the outlet. It is not recommended at present that data taken for one outlet be used for another, but in case such a procedure is found desirable the effect of friction in the barrel should be considered.

If the tube is only partly full at the outlet end both d_2 and h_2 should be measured to the water surface at the end of the barrel. Fig. 3 is not applicable to such cases.

It is not expected that a head gate can be made to serve as an accurate measuring device, as compared to the weir, but it may be possible, by following the procedure recommended, to secure more consistent results than have been obtained in the past. It is suggested that all such ratings made in the future be submitted for publication in the form of data cards, if found suitable.

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*From the May Reclamation Record.

Classification of Water Consumers and Income at Council Bluffs, Ia.—The following table from the last annual report of the Board of Waterworks Trustees of Council Bluffs, Ia., gives a classification of the water consumed and the income from each class for the past three years:

Classification.	1919 Percentage water used.	Income, per cent.	1920 Percentage water used.	Income, per cent.	1921 Percentage water used	Income, per cent.
Commercial	72.88	56.07	67.49	48.91	68.60	44.05
Domestic	16.04	38.08	17.14	34.97	20.52	37.01
W. Wks. operation.	0.37	0.00	1.59	0.00	0.40	0.00
City of Co. Bluffs..	3.75	5.85	3.75	16.12	3.75	18.94
Leaks and losses ..	6.96	0.00	7.03	0.00	6.73	0.00
	100.00	100.00	100.00	100.00	100.00	100.00

Metering of Los Angeles*

By GEORGE READ,

Superintendent Meter and Service Department, Bureau of Water Works and Supply, Los Angeles, Calif.

On Feb. 4, 1902, the municipality of Los Angeles purchased the properties of the old City Water Co. At this time the city was growing rapidly and the water supply was, if anything, diminishing due to a cycle of dry years. The daily per capita consumption at this time was 300 gal. about twice as much as it should be, and something had to be done quickly to conserve the available water supply. After considerable discussion it was decided that the only practical way to conserve the water supply was by the installation of meters.

At the time the works were taken over there were 319 metered services supplying livery stables, laundries, wineries, the oil fields and a few lodging houses. These were under a meter rate because it was hard to set a proper flat rate.

As an opening wedge, meters were set on residences where the irrigated grounds exceeded two and one half times the area of the buildings. For a short time there was considerable opposition. The business section was next given attention, and here the greatest saving was made as the plumbing, in most cases, was found in deplorable condition. Next the meters were set in those districts supplied with pumped water. From then on up to the present time meters have been set as fast as funds and time would permit. There are still 2,500 services to meter. In 1912, ten years after the works were purchased, a study of consumption through 41,177 metered services showed a maximum per capita daily of 147.9 gal. for July and a minimum of 92.35 gal. for March. The average daily per capita for the year was 118 gal. These results were based on five persons per service, which was very close to being correct at that date.

Los Angeles always will have a higher per capita consumption than most eastern cities on account of it being a city of lawns and shrubbery which need watering about ten months out of the year. This per capita referred to covers metered services only. There is considerable water used outside of these for street washing, parks, fires, sewer flushing, municipal building, etc., and today this combined is estimated to make an average daily per capita consumption of 130 gal., and reaches a high peak at times of 160 gal. Due to the increase of apartment houses the number of consumers per service today is about 5.4.

Method of Meter Setting.—As we are not bothered with freezing, our meters as a rule are set just inside the curb. They are placed on a riser from the service so that the face of the register is about 3 in. from the surface. This makes the reading of the meters and the changing of inactive meters, etc., easy and quick, and it also allows the use of an inexpensive shallow meter box.

We have a local building ordinance which prohibits basements under sidewalks extending further than 3 ft. from the curb. This strip was reserved by the city for the installation of fire plugs, meters, electrical conduits, and other public utility equipment.

We have a few meters in basements where the basement extends to the curb. These basements were made prior to this ordinance. The few that we have are a nuisance. The meter-readers must get permission to enter, hunt keys and carry flash lights. Stuffing boxes are likely to leak and to cause damage. There is also a likelihood of a meter bursting and causing a great deal of damage.

When a large service must be metered in a basement we prefer a battery of 2-in. all bronze meters with valves governing the inlet and outlet of each meter. We consider a 2-in. all bronze meter not near as likely to burst as a 3 or 4-in. meter with main casing made of cast iron. In addition, if one meter stops operating it can be changed without shutting off the entire supply. Batteries have advantages and also disadvantages.

On services supplying large industrial plants, where at times it would be inconvenient and costly to the consumer to have the water cut off while changing the meter for repairs, we place a valve on each side of the meter and run a bypass pipe equipped with a valve around the two valves governing the meter. The bypass valve is left closed and sealed and when it is necessary to change the meter for repairs, etc., we open this bypass valve and then close the two valves governing the meter, thereby not interrupting the service.

Meter Covers.—For covering meters in parkings, lawn or no lawn, a cement meter box 9 in. square by 11½ in. deep, is used—what we call our no. 1 meter box.

This box does not cover the curb cock and in fact we try to discourage the using of curb cocks by the consumer and recommend that they have a wheel valve placed by a plumber to control their water supply in case of needed repairs to leaky fixtures. The reason we try to discourage the consumer from using the curb cock is that in many cases they ruin them and frequently leave a hole dug out in front of the meter box which is a menace to the public.

We have specifications covering our curb cocks from ½ to 2-in. and they are standard all over the system. If any curb cock has to be renewed the space for the setting of the meter is retained. We also have a standard (fool proof) locking device for our curb cocks. By fool proof we mean that no curb cock can be clamped and sealed unless it is closed. Just before the world war broke out we were intending to cover meters in well kept lawns with a concrete meter box large enough to cover meter and curb cock both, and we still intend to do this when times get back to normal.

For housing meters set in cement walks we use a concrete well and a cast iron plate, large enough to house the meter and the shut off. A wooden form made from 1x12 R. O. P. rabbited ¾x¾ is set in position and concrete poured around it. The plate then rests on the wooden form while the concrete is setting. Three sizes of plates are generally used as follows:

For covering ⅝ to 1-in. meters, the plate is 23½x15¾ in., weighs 60 lb. and costs at this date $3.00 each. For covering 1½ and 2-in. meters, the plate is 30x22 in., weighs 121 lb. and costs $6.00 each. For covering 3 and 4-in. meters, the plate is 46x26 in., weighs 180 lb. and costs $9.00 each. We also have a large plate, 64x26 in., which we use at times to cover a fire-service gate and domestic meter.

When a sidewalk is being extended to the curb, taking in small concrete meter boxes that do not cover the curb cock, the department requests the contractor to leave the top of the boxes level with the surface of the new walk and cement around them. Later on when the walk is thoroughly set, and it is convenient to the department, a meter plate according to the size of the meter is laid on the sidewalk square with the curb, so that the meter register comes in the center of the plate. A hole in the sidewalk is then cut about ¼ in. larger than the plate, taking care not to crack the walk outside of the mark. The hole is excavated to about 3 in. below the bottom of the meter and the sides and ends of the hole extended about 2 in. under the walk. After the bottom of the hole is tamped, a wooden form is set covering the meter and the cut off. The plate is then set on the form and tamped down until the top of the same is level with the sidewalk. The plate is then removed and concrete is grouted all around the form to the surface. The plate is then put back and rests on the form while the concrete is setting. In time this wooden form rots away and leaves the plate resting on the concrete. A hole is left in the ends of boxes in case piping to meter has to be renewed.

This method of setting meter boxes and plates eliminates the cost of resurfacing, matching colors, covering while setting and gathering covers.

Meter Testing.—Meters are tested before they leave the factory, but to make sure they are correct the city again tests all meters before they are set. Our shop is equipped with three round galvanized iron tanks 22 in. in diameter by 4 ft. 11 in. high for testing meters from ⅝ to 2-in. Each tank is equipped on the outside with a ¾-in. O. D. glass tube, running the entire height of the tank. These glass tubes are equipped with buret floats on account of capillary attraction of water and graduated in three stations, viz., beginning point, 5 cu. ft., and 10 cu. ft., which is stopping point. These buret floats have projections to keep them from adhering to the glass tube, and contain enough quick-silver to about half submerge them. The inlet is at the bottom of the tank and the piping is so arranged that the head of water is killed when entering the tank, allowing it to rise steadily in the glass tube, so when whipped off at any flow it remains still. The 5 and 10-ft. stations are determined by weighing the water into the tank at 62½ lb. per cu. ft., so when a meter is tested the water is practically weighed through the tank reading.

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*Abstract of a paper presented before the California Section of the American Waterworks Association.

These tanks were made tall and small in diameter to insure a big displacement for a small amount of water. Each tank is used to test four or five meters at a time by connecting them together with meter couplings. These meter couplings are joined together with a tee equipped with a lever handle valve for running each meter up to an even figure.

The register boxes of all meters are sealed after testing and no meter is taken from the meter shop for setting unless it is sealed.

We also have a large reinforced concrete tank 13 ft. 10 in. square on the outside. This tank is divided into three sections. One section contains 900 cu. ft., one, 100 cu. ft., and one, 10 cu. ft. It is also equipped with a glass tube and buret float and is used for the testing of larger meters, etc.

During the last fiscal year the department tested an average of 2,000 meters per month.

Our testing tanks are kept clean and are satisfactory in every respect.

Meter Registration.—A great many people really believe that water meters rob them by over-registering, and request that their meter be tested. We explain and try to talk them out of having it done, but sometimes the more we explain the more determined they are to have the test made. We then take their order and request that they or someone witness the test and tell them that if we find the meter over-registering, that there will be no charge for the test, and that we will rebate the back bills already paid. The charge for testing is as follows: ⅝ to 1-in., $1.50; 1½ to 2-in., $2.50; 3 and 4-in., $5.00; 6 and 8-in., $6.00.

The ⅝ and 1-in. as a rule are tested at the premises, by shutting off the water, taking the meter out and connecting it to the curb cock with a piece of hose. Then a meter of known registration on variable flows equipped with a valve on the outlets side is connected to the meter to be tested. Larger sizes are taken to the shop to be tested, leaving a new meter in its place, and if the meter being tested is low in registration or needs any repairing it is not put back. In 20 years of experience I cannot recall over two cases where meters were found over-registering enough to warrant any rebate and those were very small.

Meter Repairing.—Practically all meter repairing is done at the meter shop. The only work done in the shape of repairs to meters in the field is the renewing of registers that have been broken. Main casings of our velocity meters are left on the service. The cover containing gear train and register is removed and the cage containing propeller is taken out. These parts are then replaced with new ones and the old parts are brought to the shop for repairs. This eliminates a lot of hard and costly work.

Our facilities for repairing and testing meters are very good. The shop contains concrete benches for testing, repairing and storing the meters ready for setting. The machinery consists of a lathe, pipe threading machine, wire wheels for cleaning the outside of meters and exhauster for carrying away the dust, grind stone and carborundum wheels, circular saw for cutting lumber for meter box forms, ball socket machining machine, gages, press diaphragm cutter, etc. The machinery is run by six induction motors. Our force consists of a superintendent who passes on meter parts, whether they are to be repaired or wholly replaced, and sees that every meter is properly repaired (not tinkered with). He also takes care of all repairs to service equipment.

Under him are two testers, a machinist (considered a meter repairer) and five meter repairers. A chief clerk and assistant make permits for street excavations, check meter and service work done against daily time cards, make monthly inventory of meters in stock for Los Angeles, San Pedro and San Fernando Valley, post maintenance cards, order, receive and record meter and service supplies, make monthly reports of all meters set and check these with office records, and are responsible for all meters leaving the shop. On Sept. 1, there were 126,052 meters in service, which at this date means one meter repairer for each 21,000 meters in service. The department takes out monthly about one meter for every two hundred in service for not operating, due to all causes.

In the last 12 months 161 meters were taken out monthly for failure to operate, due to hot water or steam backing up from boilers or heaters. On the first occurrence of a meter being damaged by hot water or steam supplying a residence, a post card is mailed the consumer, notifying him and requesting that care be taken to guard against a similar occurrence. On the second occurrence, a bill is rendered the consumer covering the cost of changing and repairing the meter. When meters are likewise damaged, supplying places of business, a bill is rendered on the first offence. The department advises consumers to watch their heaters and not to use a check valve on their service, as it is cheaper to pay for repairing meter than to run the risk of bursting a boiler.

Organization of Meter and Service Department.—The organization of the meter and service department consists of a general superintendent with four assistants. One has charge of the field meter and service operation and office meter and service records. The second has charge of meter and service installation and service maintenance. The third has charge of all meter repairing and upkeep of service equipment and the fourth receives, records and distributes service orders and is a general assistant.

The total force of the meter and service department at this date consists of 105 men, and they cover Los Angeles, San Pedro, San Fernando Valley and the West Gate District.

The city of Los Angeles was incorporated on April 4, 1850, and at that date its total area was 28 square miles. Today it covers an area of 366 square miles, a square mile for every day in the year.

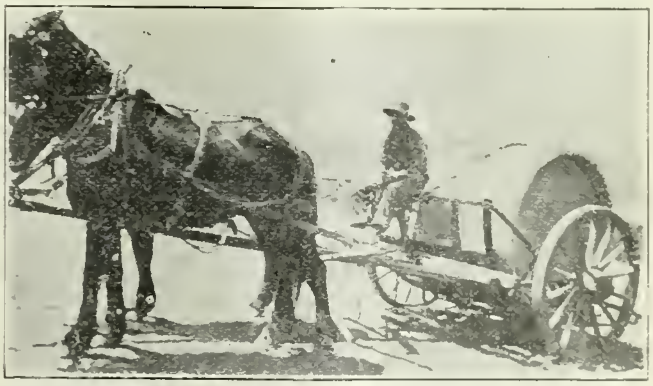
The new domestic service installations for the last twelve months, covering all districts, have been at the rate of 1,025 per month, and today show no signs of falling off.

On Sept. 1, 1921, we had 136,970 services of all kinds and 123,052 meters. We have also a little over 3,000 irrigation services and meters in the San Fernando Valley, which makes a total of 126,052 meters to maintain.

Special Rig for Hauling Concrete Pipe

For hauling concrete pipe to be installed in a conduit system near Salt Lake City, a special rig was devised by the Engineering Department of Salt Lake City, Utah, Sylvester Q. Cannon, city engineer. The arrangement is described in a recent issue of Concrete.

The rig consisted of a 2-wheel cart with a cradle body, hung low on gooseneck axles. Several of the rigs were used in transporting the pipe, made at a central casting plant, and the average haul for each outfit was from 14 to 17 miles a day. The pipe line was 17,100 ft. long, and laid at the rate of 275 to 300 ft. a day of 8 hours. The pipe sections were 4 ft. long and 48 in. in diameter, and weighed 3,200 lbs. This type of rig made the hauling as well as the loading and unloading of the pipe an easy job.



Special Cart for Hauling Concrete Pipe.

Committee to Review Treasury Department Standard for Drinking Water.—A committee known as the Advisory Committee on Official Water Standards has been appointed by the Surgeon General of the U. S. Public Health Service, with the approval of the Secretary of the Treasury, to review the present Treasury Department Standard for Drinking Water on Interstate Common Carriers and to recommend a standard, or standards, based on recommended specific methods of laboratory analysis and field survey which will be applicable to all classes of water supplies coming within the supervision of the Interstate Quarantine Regulations of the United States.

Motor Driven Centrifugal Pumps with Gas Engine Standby

Experiences of Champaign and Urbana Water Co., Related in Paper Presented at Last Annual Convention of Illinois Section American Waterworks Association

By W. B. BUSHNELL,
Supervising Engineer, Champaign & Urbana Water Co., Champaign, Ill.

Prior to 1917, the Champaign & Urbana Water Co. generated all the power required for the operation of its pumping equipment. During this year, however, it entered into a contract with the Urbana & Champaign Railway, Gas & Electric Co. to purchase all the electric power it required from them. This decision was reached principally because of the following conditions:

The power company offered to enter into a contract to furnish electric power at rates which very closely approximated the cost at which the water company was producing it.

The signs of the times indicated that the future source of cheap power was likely to be from large generating stations which transmitted and distributed the power over extensive territories.

The water company would in a comparatively short time be compelled to install additional electrical generating equipment in order to meet its demands.

A contract was entered into and a connection was made to the Urbana & Champaign Railway, Gas & Electric Co. power plant. About the same time another connection was made to the power plant of the Urbana Light, Heat and Power Company. This latter connection is used only in case of failure of the supply from the former company.

The water company continued to maintain as a standby unit one 2,500,000 gal. per day Laidlaw-Dunn-Gordon steam service pump. It also maintained in service as standby equipment a 200 KVA generating unit which was of sufficient capacity to generate the power necessary for the operation of its well pumps. These gave an additional assurance of the continuity of water service The service was maintained in this manner until 1921 when the demand on the water company's plant became sufficient to require the installation of additional service pumps.

It was necessary, at this time, to put into operation all of the motor-driven pumps in order to furnish adequate fire pressure. The regular domestic service was then supplied by two 1½ MGD centrifugal pumps which could be operated either in parallel or in series. During a certain portion of the day both these pumps were required to furnish domestic service. It was therefore decided that any additional units should be of 3 MGD capacity.

By this time the demand had reached a point at which the Laidlaw-Dunn-Gordon steam pump was inadequate to carry the load in case of total failure of the supply of purchased power. It was, therefore, decided that additional standby equipment should also be supplied

Centrifugal Pumping Units.—To meet the combined need of equipment for normal operations and for standby service, two centrifugal pumping units were installed, each consisting of:

One 8-in. single stage, double suction DeLaval centrifugal pump connected at one end through special jaw coupling to one 145 H. P. model FC-6 Sterling gasoline engine, and at the other end through a flexible coupling to a type KT-General Electric, 3-phase, 60-cycle, 220-volt squirrel cage motor with starting compensator.

The pumps were designed to deliver 2,100 g. p. m., against 127 ft. total head, having a guaranteed efficiency of 78 per cent at speed of 1,160 r. p. m., and to permit of operation either in parallel or in series. When the pumps are driven by the gasoline engine the motor rotors are allowed to float.

On March 22, 1921, when the two units were put into operation there became available for stand-by service a total domestic service capacity of 8½ m. g. d., or a total fire service pumping capacity of 5½ m. g. d. The 200 KVA generator was continued in operation so that the plant was in a position to maintain continuous service under extremely adverse circumstances.

Installation Features.—Some interesting features in connection with the installation and operation of these units will be briefly given below:

The pumps were set at right angles to each other, a position necessitated by the available floor space, and it is of interest to note that had the same pumping capacity been provided by means of steam pumps an addition to the pumping station building would have been necessary.

These pumping units have a common suction line which is 18 in. in diameter and 180 ft. in length to the point at which the nearest pump obtained its supply. The pumps may be thrown in parallel or in series by means of hydraulic valves. The small valves which control both hydraulic valves are in one place so that their joint operation is quite easily accomplished.

There was quite a little difficulty experienced in setting these pumps, which might have been eliminated had there been one or two flexible connections in the pipe lines instead of being all of rigid flange connections.

The Gasoline Supply.—The gasoline supply for the engines is stored in two tanks of about 60 gal. each, buried in the ground outside the building. The gasoline is forced to the engines by means of air pressure created by an air pump which operates to fill a storage tank which may be made to feed into the gasoline tanks. The gasoline piping is so arranged that either one of the tanks may be drawn from and it is the practice to keep one cut out at all times so that should the engine stop from lack of gasoline a full tank will be available and warning given that the other tank should be filled. The combined capacity of the two tanks is sufficient to operate both engines at full load for about five hours. A Standard Oil station is within two blocks of the plant and arrangements have been made with the attendant whereby it is possible, in case of necessity, to obtain gasoline at any time of day or night. For this reason it is deemed sufficient to carry a maximum supply sufficient for five hours' run under fire service conditions.

Maxim Silencers for Gas Exhaust.—The exhaust from the engines is carried outside of the pumping station building and there passes through Maxim silencers, which very efficiently perform the duty for which they were designed. In fact, the noise from the exhaust is barely audible for a distance of 200 feet. This is somewhat in contrast with the noise of the running engines within the building which is especially noticeable because of the quiet operation of the motor driven centrifugal pumps. However, this is not an especially objectionable feature for stand-by equipment, due to the comparatively short duration of time that they are called into service.

The gasoline engines are equipped with self-starters and generators for charging the storage batteries required for same. The generator is regularly installed from the shaft geared to the main shaft of the engine. This arrangement would, no doubt, be quite satisfactory for an engine which did not start often and then ran for quite a period of time. These engines, however, are started twice a day and run only a few minutes at low speed for testing. Under these conditions it was found that the batteries were not maintained in a charged condition. For this reason the generators were placed so that they might be operated by the shaft on the motor side of the pump. In this manner the charging may be continued during the normal operation of the pumps.

There has been but one occasion upon which these engines have refused to start and this could be traced to the use of a poor grade of oil. Upon investigation at this time it was found that the spark plugs were so badly carboned that it was surprising that the engines had not refused to start long before. The trouble was eliminated by using a different grade of oil.

The Storage Batteries.—Some investigation has been made of the storage batteries. It was found some time ago that they had reached a point where all the cells could not be charged as they should. The results of the investigation were that the starting current for the first second or two was 130 amps. and then dropped to 80 amps. As these batteries are of 50 amp.-hour capacity it will be seen that under the nature of service they are required to perform, they are called upon to stand quite a little abuse. Batteries of sufficient size to perform this service without being abusive would necessarily be quite large and cost a considerable sum. It was, therefore, concluded that it would be better to use batteries of the present size as long as they would perform the work required of them and then buy new ones about the same size.

The normal pumpage during the greater part of the day is taken care of by one of these pumps. When it is necessary to furnish fire pressure these two pumps are thrown in series as well as other pumps. In the process of throwing these pumps in series, at a time when the water in the reservoir is below the pump suction, it is possible to manipulate the control valves so that one pump will lose its suction. This can be prevented by proper opening and closing the valves in proper order, but we found upon one of two occasions the valves were not properly operated. In order to provide a quick remedy for human error in this regard a No. 0 Nash vacuum pump was installed so that it is driven from pulley in the shaft of the pump. By means of this the prime can be regained in somewhat less than a minute.

From the experience of operating these units for the past year we are of the opinion that the gasoline engines provide a very satisfactory method of providing stand-by power.

Care of Fire Hydrants

The methods of the Terre Haute (Ind.) Water Co. in taking care of its fire hydrant system were described as follows by Mr. Dow R. Gwinn, president of the company, in a paper presented at the last annual convention of the Indiana Sanitary and Water Supply Association:

For a number of years, it has been our policy to use 6-in. branch connections to hydrants with a 6-in gate valve on the same so that repairs may be made without shutting off the main line and possibly other hydrants.

All fire hydrants have brick drain pits at the base, opposite the drain openings. These pits are open at the bottom and are about 1 cu. ft. capacity. They facilitate the quick draining of the hydrants.

Hydrants are flushed in the spring and autumn—usually in April and September. This is for the double purpose of cleaning the distribution system and for examination of hydrants—to determine if they are in good working order. On the occasion of a recent flushing, two hydrants were found to be broken below the surface of the ground; there was nothing in their appearance that would indicate that they were broken. In the past two years, we have had about 20 fire hydrants broken by automobiles. In a number of cases, the broken hydrant stocks were welded at a cost of about $8 each. A record is made of hydrants that are hard to open, those that do not drain, that leak through the waste when open fully, and any that require attention. These are attended to promptly. All our fire hydrants open by turning to the left. We have a hydrant with a portion of the stock and frost case cut away; this is used to show the fireman how a hydrant is operated.

THE TERRE HAUTE WATER WORKS CO.
Fire Alarm Record.
Date .... 19.
Location of fire ....
Alarm received (time) ....M.
Alarm received by ....
Box No. .... By A. D. T. No. ....
Average fire pressure, outlet of filters ....Pounds
From ....M. to ....M.
Time of receiving second alarm ....M.
Notified Mr. ....at.............M.
Notified Mr. ....at.............M.
Notified Mr. ....at.............M.
Notified Office, Mr. ....at.............M.
Strike out signal received ....M.
Strike out signal received by ....
Pumpage rate, No. 7 ....No. 5............
No. 4 ....Total Rate.........
Remarks
....
....
....

RECORD OF FIRE HYDRANTS USED.
CHARACTER OF FIRE, ETC., ETC.
Hydrants Used and Condition After Fire.
Location Condition
....
....
Remarks
....
....
Inspection made this .... day of .. ..19....
....
Inspector.
Fire Loss $............

Fig. 1—Form for Reporting Condition of Fire Hydrant.

Inspections are made just before winter begins and the most important hydrants are inspected from time to time during very cold weather. This is done by removing the nozzle cap and dropping into the hydrant, a weight attached to a cord. Notwithstanding our repeated inspections, we occasionally find a hydrant with water in it, due to ground water getting in through the drain opening or through a small leak in the main valve.

We carry in stock hydrants of different sizes and makes and these are substituted for those that are out of order. By this plan, the hydrants are available promptly for the fire department, and we repair the removed hydrants when convenient.

If a hydrant should be found with ice in it, salt and hot water are used for thawing.

The fire chief is notified immediately when a hydrant is found out of order, due to being broken by automobiles or to freezing; also whenever it is necessary to shut off a main line. This information is sent out by the chief to the different fire houses. When a hydrant is restored to service, the chief is notified.

Fire hydrants are for extinguishing fires and as far as possible should be kept sacred for that purpose. When water is needed by the city for flushing a sewer, we are notified and our man goes out, attaches an auxiliary valve on one of the nozzles and then opens the hydrant full. The city men use the auxiliary valve and when through with the water, they telephone our office and our man closes the hydrant and removes the auxiliary valve. No charge is made for the water for the time. When water is furnished for a circus or to a contractor from a fire hydrant, we use auxiliary valves, but our man remains on the ground and we are paid for his time as well as the water.

When a fire alarm is received, a record is made of it and one of our inspectors is given an order to examine the hydrants that are used and report on their condition. The blanks used for this report are shown in Fig. 1.

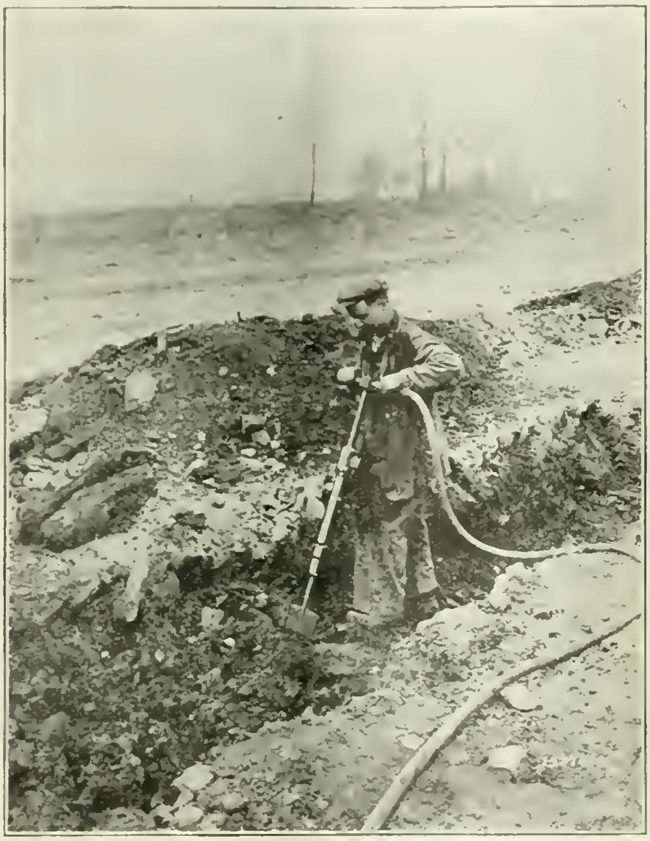
Device for Welding Hydrants

A home made device for welding broken hydrants developed by the Maintenance and Repair Division of the Rochester, N. Y., Waterworks, is illustrated. In this arrangement the barrel of the hydrant is kept in alignment by a rod running through its center. A thread is cut on each end of the rod to carry a plate and lock nut. The height is adjusted by four holders. The hydrant revolves on rollers, thus relieving the strain on the barrel. Geo. E. Cripps is Superintendent of the Division of Maintenance and Repairs.

Rochester (N. Y.) Water Department Device for Welding Broken Hydrant.

Trench Excavation with Pneumatic Clay Digger

Another substitution of mechanical methods for slow and costly manual labor has apparently been made in the case of a new air operated tool that does the work of ordinary hand picks. With this new tool it now seems probable that laborious hand picking can be dispensed with on many excavation jobs with a considerable saving over former hand methods. On many digging jobs in stiff clay and hard soil for trenches, shafts, tunnels, etc., the ground is not hard enough to be drilled and shot, and yet it is too hard to be removed with the ordinary hand shovel alone. Where a large power driven machine cannot be worked the usual procedure is, of course, to employ a gang of men with hand picks to loosen the ground for hand shoveling. This new air tool has been developed for use by contractors to eliminate most of such hand pick work. With one of these pneumatic diggers it is claimed one man can ordinarily loosen as much ground as five men with hand picks.



Little David Clay Digger (Extension Handle Type) Being Used in Trenching.

The compressed air operated tool and its manner of use in trenching are shown in the accompanying illustration. It is a tool of fairly light weight (23 lb. complete) which a man operates while standing in an upright position. It is, briefly, an air hammer with a cross-bar extension handle being 34 in. in overall length. A digging blade is held in the nozzle end of the hammer by a suitable retaining device. In operation the blows of the hammer drive the blade into the clay or hard ground so that it is pried loose. For clay the blades are approximately 6 in. x 8 in. of a slight scoop shape. For earth they are 5 in. x 9 in. rectangular with a flat face ⅝ in. thick at the top and 5/16 in. thick at the bottom with the cutting edge beveled from the back.

The throttle is conveniently located in the grip handle so that the air can be readily shut off as the tool is lifted from one position to another. A buffer inside the retaining nozzle takes the blow if the hammer is operated while the tool is being lifted. An operator, however, soon learns to automatically shut off the air as soon as he starts pulling up on the handle.

This tool is being manufactured by the Ingersoll-Rand Co., 11 Broadway, New York, and is known as the No. 56H "Little David" Clay Digger (Extension Handle Type). As the name implies, this tool is a development from the pneumatic diggers used in tunneling through clay, the same type hammer being employed in both tools.

Water Rates and the Advantages of Meters

In the 8th annual report of the Water Department of Kalispell, Mont., Mr. W. H. Lawrence, Superintendent of Waterworks, has the following to say regarding rates and meterage:

> The operation of a municipally owned plant affords the opportunity for rates on the basis of true equity and free from temptation to adopt policies of financial expediency appealing to privately owned plants. The functions of a water works plant are admittedly two-fold, that of furnishing a water supply for general consumption and for fire protection. "The Rates Charged for Any Service Should Be in Proportion to the Cost of Such Service." It, therefore, becomes necessary to make a careful analysis of all functions and duties assumed by the water department and all services rendered.
>
> The flat rate method of charging for water service, a heritage to us from pioneers in the water works field, carries the approval of the wasteful user, because it permits his extravagance at public expense. It would seem, therefore, to devolve wholly on the water department to gradually make obsolete the flat rate system, as flat rate charges or assessments are admittedly inequitable and conducive to wasteful habits.
>
> In the sale of any commodity, and water is a commodity, there must be in all fairness some basic principle upon which its costs of production and sale can be established, so that each individual interested may receive equitable results. "In other words, the cost of service is made the legal basis for rates." The method of stopping all illegal practices is to have every service metered; then if a man wants to pay for wasted water, he can do so and his neighbor does not shoulder the greater part of the cost. The office of the meter should not be to restrict the legitimate use of water, it never did, and it never will, but it does secure to each consumer an abundant supply for all purposes at a minimum cost on an equitable basis.
>
> The lowly meter is regrded by some householders with distrust, but is in reality, a faithful servant. We have shown many of our consumers that leaks were responsible for abnormal water bills, not the inaccuracy of the meter. We have urged consumers to read their meters, and keep track of water consumption, pointing out that where the meters are read every few days, leakage is discovered and may be checked before it affects the bill. "The meter is a great leak detector."
>
> The consumer who reads his meter is in a position to verify his water bill. He does not think of the meter with distrust. He has no occasion to enter into "heated discussions" over the correctness of meter readings. He is making his water meter serve to the fullest extent.

Personals

John Robinson has been appointed superintendent of waterworks of Kenmore, O

C. J. Corcoran has been appointed superintendent of waterworks of St. Helena, Calif.

F. H. Todd, El Paso, Tex., has been appointed city engineer of Tularosa, N. Mex.

J. M. Wanzer, formerly an engineer of the California State Highway Department, has been appointed city manager of Marysville, Calif.

M. P. Tucker, superintendent of waterworks of Akron, O., has been appointed service director of the city. Mr. Tucker will continue to supervise the operation of the waterworks, with A. S. Hibbs as assistant.

David W. Brunton, Denver, Colo., and J. Vipond Davies and J. Waldo Smith of New York have been selected by the Moffat Tunnel Commission of Denver as a board of consulting engineers for the 6-mile tunnel to be driven through the Continental Divide.

Dr. Herbert H. Forbes, formerly dean of the College of Agriculture of Arizona, and lately agronomist of the Royal Agricultural Society of Cairo, has been selected by French colonial authorities to report on a project of irrigation in the Niger valley in West Africa. The work contemplates an irrigation dam similar to the Assouan dam of the Nile, to be carried out under the direction of the governor-general of French Occidental Africa.

Wynkoop Kiersted, consulting hydraulic engineer, has associated with himself Henry A. Stringfellow, under the firm name of Kiersted & Stringfellow, with offices at 611 Interstate Bldg. (13th and Locust Sts.), Kansas City, Mo. The firm will specialize in waterworks engineering, the standardization of power and pumping stations and water purification works, design of steam, electric motor and oil engine driven pumping plants, the valuation of water works properties for purchase and sale or rate-making purposes.

James E. Sellers, assistant engineer on the Verde River Water Project for the City of Phoenix, Ariz., has resigned and is now completing a report on the Colorado River flood control for Chicago interests Mr. Sellers was in complete charge of the design and construction of the $2,000,000 water project for the City of Phoenix and has completed the work in record time. Mr. Sellers served 18 months in France with the 23rd Engineers. He will become associated with a Chicago firm and handle their western business from San Francisco.

Industrial Notes

The Younglove Construction Co., United Bank Bldg., Sioux City, Ia., has been appointed representative of the Conveyors Corporation of America, 326 W. Madison St., Chicago, Ill., for the sale of American trolley carriers in northwestern Iowa and South Dakota.

W. H. Kent, vice-president and general manager of the Weller Manufacturing Co., left Chicago one June 28 for an extended trip throughout the European countries. Investigation will be made as to the possibilities of future trade, also inspection of Weller equipment installed in a number of the large plants.

S. Glen Vinson, secretary and general manager of The Ideal Electric & Manufacturing Co., of Mansfield, O., left April 15 for the Orient, where he will make a survey of business conditions. Mr. Vinson will include on this trip all the larger cities in Japan, China, Philippine Islands and India. He expects to return to the states about October 1.

Railways and Excavation Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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The Supreme Court Again Rules Against Actual Cost as Basis for Rate Making

The U. S. Supreme Court has repeatedly decided that not the actual cost but the present value of a railway or other public utility plant should be the basis for rate making; but the great increase in cost of reproduction that has occurred has led many engineers and utility commissions to argue that the Supreme Court must now reverse its former decisions. Some slight chance that the Supreme Court might reverse itself on this important point seemed to be found by "reading between the lines" of the recent Galveston street railway decision. But now comes a later decision that clearly reaffirms the doctrine that original cost is not a proper basis for rate making. We refer to the decision delivered by Mr. Justice Clark on May 29, 1922, in the case of Southwestern Bell Telephone Co. vs. City of Houston (Texas).

In this case the Bell company had bought out and merged the Houston Home Telephone Co. that had operated under a 1909 ordinance in which the provision occured that the company "agrees that it will not increase rates as at present charged by it for service in the city of Houston, unless it appears upon a satisfactory showing * * * that there exists a necessity for an increase of charges, in order that the said company may earn a fair return upon its capital actually invested in the Houston plant."

The Supreme Court decides:

"We think that neither party was bound by the ordinance and the acceptance of it, that the District Court fell into error, and the proper base for rate-making in the case is the fair value of the property, useful and used by the company at the time of the inquiry."

The issue between investment cost and present value was raised in this rate case even more clearly than in any other that has ever come before the Supreme Court, yet the Court decided against investment cost.

Another much debated point was touched upon in this decision, namely, "going concern value." The master had allowed a "going concern value" equivalent to about 17 per cent of the cost of the plant; but the District Court concluded that under the agreement in the merger ordinance no such allowance should be made. The Supreme Court says:

> Whether going concern value should be considered and allowed at all in determining the base for rate making, and if allowed, what the amount should be, depends upon the financial history of the company (Galveston Electric Co. vs. City of Galveston, et. al., decided April 10, 1922), and it is impossible for us to determine whether the requisite history for deciding this question is to be found in these large volumes of the transcript of the record of the case, containing 1,664 pages, without reading the whole of it.

The Supreme Court has rules requiring indexing and briefing records of this sort, which rules were apparently not obeyed by the attorneys, so the Court refuses to read the record to ascertain whether there was any "going value" in this case. But the Court indicates that it would have allowed such a value had it been proved. What is more significant, the Court apparently favors a "going value" based on the history of the company. This seems to be at variance with the Court's doctrine that the value of the plant is not based on its actual or historical cost.

The Galveston decision left this matter of "going value" in a fog, for Justice Brandeis seemed to reject "going value" based on the history of the company, and indicated no other form of "going value" that would be approved. Now comes Justice Clark and actually cites the Galveston decision as favoring a "going value" based on the history of the company!

To a layman it is somewhat mysterious that Justice Brandeis did not call Justice Clark's attention to the fact that there was nothing in the Galveston decision (which Justice Brandeis delivered) that favored a "going value" based on the history of the company, but quite the contrary. Is it possible that our Supreme Judges are so busy that they do not read carefully the decisions written by their own associates? Or, if they do, do some of them occasionally fail to remember the principles that they themselves laid down in previous cases? One of these alternatives seems unescapable.

However, the Supreme Court has repeatedly ruled that "going value" must be included in the value for rate making, but it has not yet announced a rule by which "going value" is to be estimated.

The Congressional Bill to Exclude "Acquisition Costs" from Right of Way Valuations

It is fortunate, indeed, for the owners of railway and other public utility property that there is a written Constitution and a Supreme Court to interpret the Constitution. Both houses of congress have passed a bill that has gone to the President, amending the railroad valuation act in a manner that violates property rights. It is a matter of little practical concern whether the President signs the bill or not, for the Supreme Court will unquestionably declare unconstitutional any law that prescribes, as this bill does, that the land of a public utility shall not be valued at its present cost of reproduction.

The Interstate Commerce Commission apparently has sponsored this bill after the Supreme Court had ordered it to find the cost of reproducing the land owned by the Kansas City Southern.

In 178 tentative railway valuations the present value of land totals about $277,000,000, inclusive of $121,000,000 cost of acquiring the land; but up to date the Interstate Commerce Commission has persistently ignored this acquisition cost, and is apparently determined to secure legal authority for omitting this unquestionable element of value. Of course the Commission could cite the ruling of the Supreme Court in the Minnesota rate case, which seems to sanction such an omission; but there is little doubt that Justice Hughes, who wrote that decision, was confused in his reasoning, and that when this "right of way multiple" or condemnation cost factor again comes before the Supreme Court it will be ruled that it is a proper element of the cost of reproduction.

In its railway valuations the Commission has persistently adhered to the original cost theory, which the Supreme Court, just as persistently, has declared not to be a proper base for rate making.

Most of the state railway commissions have taken the same stand as that of the I. C. C., and the bill under discussion has had their support. None the less, the bill is contrary to the Constitution and, if it becomes a law, is destined to be declared so.

$500,000,000 of Public Works Contracts Let in First Half of 1922

The following weekly summary was written by the editor of Engineering and Contracting for the Chicago Journal of Commerce:

Nearly $700,000,000 worth of city, county and state bonds (long term) were sold during the first six months of 1922, which is three times as much as the average pre-war sales for the first half of each year. Since public works construction usually is about equal in volume to the total sales of such bonds, it follows that this unprecedented sale of bonds forecasts an unprecedented amount of public works construction. Exclusive of buildings, the total public works contracts awarded during the first half of this year amounted to $500,000,000, in round numbers, of which 55 per cent was for road and street construction. Highway work is therefore booming, but the same cannot be said of sewers and waterworks. Waterworks improvements are badly subnormal in volume; the contracts awarded during the last six months total only $22,000,000, at which rate the waterworks contracts will total less than 80 ct. per capita of city and village population.

This is really a serious matter, for it means a progressively increasing shortage in the supply of water. Already there are hundreds of cities that have placed a ban on lawn and garden sprinkling during the hours when it is most convenient and most desirable to sprinkle. In nearly all those cities, the fire pressure is inadequate.

The main cause of this serious condition is the indifference of city councils and the public to the recommendations of city engineers and waterworks superintendents. The public is prone to defer capital expenditures of this sort until a crisis forces action.

Sewer construction contracts totaled $33,000,000 for the first half of this year. This also is subnormal, but not so badly subnormal as waterworks construction.

The Impending Shortage of Open Top Cars and Its Significance to Contractors

Contractors should not delay in placing orders for construction materials, and should hurry up shipments, for it is almost certain that there will be an open-top car shortage soon after the coal strike is settled.

We need not hark back farther than the car shortage of 1918 when the government diverted nearly all open-top cars to the coal fields. Construction work, meager though it then was, was brought almost to a standstill in many localities, because materials could not be secured. Now that construction is booming, a car shortage will be even more disastrous.

It behooves every contractor to bestir himself before the prospective car shortage becomes a reality. Also construction associations should prepare to fight for the economic rights of the construction industry when the cry goes up to divert all open-top cars to the hauling of coal.

The Engineer as Specialist or Executive?

There is much talk pro and con about the engineer as an executive. Recently the president of a great railroad said, "Engineering is specialized work and a hard task-master. Engineers in their eagerness to increase their knowledge of engineering become completely absorbed in their work." Such men are specialists-in-facts, research men, and altruists. They are not executives, nor is it desirable that they should be executives,—men who execute, men of action. The very necessary function of the specialist is to prepare the facts for the men of action. The complete divorce of the collection of information and the formulation and execution of plans and policies is probably not only desirable but necessary for true efficiency.

On the other hand, there is a large class of engineers who are men of action dealing with men, machines, and materials. To say that the superintendent of a construction job, or the chief engineer of a railroad or machine shop is not an executive is folly.

Many practicing engineers are by nature and training executives, others are by nature and training specialists-in-facts. To generalize too much is dangerous and may lead to false conclusions. The thing to remember is that a natural executive may have been trained only as a specialist, and has lacked opportunity to exercise his natural gifts.—Editorial in Professional Engineer.

Improve Your Knowledge of Accounting

The recent appointment of a man whose training had been primarily in engineering as auditor of capital expenditures points definitely to the closer relation between engineering and accounting at the present time. This situation has been brought about by the greater attention which is being given to accounting on the railroads, and particularly by the employment of large forces of engineers on the federal valuation, but whether the work at hand concerns valuation or routine construction or maintenance, we find that the engineer must learn more about accounting, while the accountant has need of a better knowledge of engineering. The work of neither can be done without some knowledge of the other's problems. This fact was first driven home in connection with valuation and this led to the creation of such positions as engineer accountant. To advance an engineer to higher accounting positions is but another step. However, whether or not an engineer has any ambitions in the direction of the accounting department, he owes it to himself to extend his knowledge of accounting because of the intimate relation it has to the administration of the work under his direction, no matter what that may be. —Editorial in Railway Age.

Babson's Idea of Engineers as Railway Executives

The following statement attributed to Roger W. Babson appeared in a recent issue of the Cleveland Plaindealer:

The railroads were built by civil engineers. These engineers have gradually worked up until they have become the operators. They are honest, hardworking, intelligent men, but they are trained for engineers and not for merchants. Transportation today is a matter of merchandising. The construction period of railroading has gone by. There is no more reason why a civil engineer should run a railroad today than that he should run the Woolworth business or the Sears-Roebuck business.

This letter was written to Mr. Babson by Professional Engineer:

The recent newspaper article in which you are alleged to have criticized railroads for placing engineers in executive operating positions has created comment by members of the American Association of Engineers.

It seems to be an opinion among your critics that you have done an injustice to many competent men. It is our understanding that the "merchant of transportation" is the traffic department, and in talking recently with a man who has been in close contact with railroads for many years, he said that he knew of no traffic department headed by an engineer and in such capacity in charge of merchandising policy.

We should like very much to know just why this general criticism of civil engineers was made and just what are the reasons for such a general statement.

Mr. Babson replied as follows:

Thank you for your letter. The statement is nothing for the engineer to be offended at. You know that I was brought up a civil engineer under Prof. George F. Swain, Course 1, Massachusetts Institute of Technology.

I would just as strongly advise a merchant to keep out of engineering as I would advise an engineer to keep out of merchandising. I simply wanted to emphasize the fact that they are two distinct lines of business.

One thing more, by-the-way, if the railroads were operated by the merchants, and the merchandising principles applied, they would be able to pay much larger salaries than they are now.

Harriman knew the value of engineers as railroad executives and made the most of them. The sound, strong railroads are in nearly every case lines on which men with technical training have a voice in the management.—Editorial in Professional Engineer.

Not long ago, Mr. Roger W. Babson, whose statistical organization has made him a national character, got up one morning with a bad grouch and made some remarks about civil engineers that, to say the least, may detract from his reputation as a seer.

Among other things, he said that one of the things at present ailing the railroads was that there were too many civil engineers trying to run them. He seemed to think railroading is more on the order of merchandising and should be given into the hands of bankers and merchants. Now the gentleman, aside from being in bad temper when he made these remarks, most probably had left his notebook at the hotel.

Railroading is not akin to merchandising. The most efficient railroad is the one that can manufacture transportation units the cheapest. The matter of selling transportation is, of course, a serious problem, particularly in the face of all the regulations with which one must comply before the units of transportation may be sold, but the big problem of the railroads is no longer one of competition so much as efficiency. If under our present system of rate regulation the traffic does not offer itself to be hauled, something must be practiced besides mere merchandising methods. The big thing is to move the traffic that is offered at the least possible expense, and this is engineering.

Sometimes we remember hearing engineering defined as "making a dollar earn the most interest," and the belief still clings that this is a very fair definition. If so, the successful railroad is apparently faced with one big engineering problem. Had Mr. Babson consulted his engineering statistics, together with the roster of railroads, he would have discovered that the large railroad systems of this country that are most successfully managed have civil engineers in command or in their executive staffs in goodly number. The two railroads of the country that stand out in relief as being successfully managed are the Pennsylvania and Santa Fe, the latter called the "Pennsylvania of the West." We believe the success of these two railroads is largely due to their engineering personnel and the policies that mesh with engineering principles. Mr. Babson, being a great statistician, is probably familiar with the old saw, "Figures don't lie, but liars figure." We doubt, however, if he is familiar with the true definition of engineering.—Editorial in Official Bulletin of the Colorado Society of Engineers.

Seattle and Its Municipal Street Railway

Seattle, by a vote that leaves no question in anybody's mind as to whether the will of the people really was expressed, has killed the proposition that the municipal street railway system be maintained and operated out of general taxation and extensions and renewals be paid out of gross receipts. The vote at the special election on May 2 was 40,222 against the proposition and 15,281 for it.

Had this proposition been adopted the country would have seen an experiment in socialism that would have been exceedingly menacing in its possibilities, not only to transportation interests, but to all private properties. Here was a suggestion which, carried to its logical conclusion, meant that eventually the people should ride without paying fares, the total cost of operation and maintenance to be paid out of general taxation. Under such a scheme the property owners would carry the whole burden. The residents who owned no taxable property, suburbanites and visitors to the city, would ride at the expense of the working man who was trying to own his own home, the merchant, the manufacturer, the taxpayers as a whole. If this scheme had been approved, what argument could there be against free water, free gas, free electric lights, free telephone service, free groceries, free clothing, free everything? Fortunately for themselves the people of Seattle realized the fundamental unsoundness of the proposition and killed it.

One must not think that this is the end of trouble for Seattle, for when a community gets a municipally-owned public utility on its hands it has "bought something." The so-called 3-ct. fare proposition having been killed, a Councilman gives notice that he will introduce a 5-ct. fare bill. Political considerations, not economic ones, rule when a community goes into the public utility business.—Editorial in AERA.

Railroad Rate Reduction an Expedient of Doubtful Value

The order of the Interstate Commerce Commission effective July 1 cutting freight rates 10 per cent will mean a saving of from 10 to 30 cents per ton of coal consumed by electric light and power companies. Nevertheless, unless the reduction is justified by an increase in railroad business it would be better if it had never been made. No public utility seeks to profit at the expense of some other utility, nor can any utility acquiesce in a rate reduction predicated mainly on hope. When it can be shown that the railroads are earning too much money it will be time enough to cut rates. Business must be in a bad way when it will stoop to accept gratuities from the Interstate Commerce Commission.

The financial condition of the railroads is none too good though they are said to be making some money now. If they can operate and grow under the rate reduction, so much the better, but it is idle to expect any great demand for railroad securities paying perhaps 5¾ per cent and perhaps not, when better bonds paying more are procurable. It would have been far wiser to enable the railroads to get on their feet first than to curtail their incomes at this critical time. We want transportation, and, as Herbert Hoover has said, we want it with the values of private initiative and clean public service. To shake the confidence of the public in railroads as an investment, therefore, can mean only a dearth of funds, and if the railroads lack funds, business will discover that they will fail it when it needs transportation. High commodity and labor costs still plague the railroads, and to expect them to absorb any great loss in revenue due to lower freight rates is to expect the impossible. Our railroads have been kicked about and experimented with enough. It is about time that those skilled in transportation be given a freer hand and a little encouragement.—Editorial in Eelectrical World.

"The Young Man and Civil Engineering"

Problems to Be Met, Requirements of Personality and Education, Things Which Will Help the Man Who Has Selected Engineering for His Life Work

A Comprehensive Review of the Book of the Above Title by Dr. George Fillmore Swain

By DR. J. A. L. WADDELL.

This book is the third thus far issued in a series of twelve, denominated the "Vocational Series" by its publishers, The MacMillan Company. If the other eleven books (which are to deal with the principal lines of American activity) approach at all closely in thoroughness, vigor, style, uplift, diction, and general excellence this book by Dr. Swain, the publishing company will have conferred upon the youth of America a boon of inestimable value.

In profoundness of thought, altruism, breadth of vision, knowledge of human nature, forcefulness of appeal, clearness of conception, systematization of treatment, sound common sense, and masterly handling of subject, this treatise, short as it is, leaves practically nothing to be desired.

It should be read not only by every young man who contemplates joining the ranks of the engineering profession, but also by all engineering students and all young practicing civil engineers. In truth, it can be perused with both pleasure and profit by any civil engineer, no matter what his age, experience, or professional standing may be; for the old practitioner can find in its contents many suggestions of great value and importance to recommend to his younger technical brethren.

Every instructor in engineering, irrespective of how lofty or otherwise may be his position, should read the work, not merely once, but several times—often enough, in fact, to impress its contents so thoroughly on his mind that, at any time, he may be able to quote to his students the substance of its contents whenever the opportunity to do so arises.

To review such a work effectively, one should make numerous quotations from the text, choosing the most salient and important features thereof; but in so doing he is constantly tempted to excerpt more material than would be compatible with the brevity that is customary in preparing reviews of technical literature for engineering periodicals. The reason for this is that, in spite of its two hundred pages, the contents are condensed to the limit of consistency and advisability. No subject treated could well have been omitted, and there is no padding anywhere. From cover to cover the book is replete with sound advice, based upon long experience in both technical teaching and active engineering practice, all offered in such a manner as to please the reader while, at the same time, imparting valuable information and proffering sage counsel. It is, therefore, quite difficult to decide upon what topics to exclude when reviewing and upon how much to quote from the discussion of each topic retained. It has proved necessary to omit from consideration many subjects which the reviewer would have delighted to include; but he hopes that the quotations he has made will prove so interesting to the readers of Engineering and Contracting as to whet their appetites for more, and thus induce them to purchase and read the book and enjoy its many excellencies of style, thought, and diction.

The work is divided into seven chapters, of which the titles are as follows:

I. Historical Introduction.
II. Branches of Civil Engineering.
III. Qualifications Necessary or Desirable for the Civil Engineer.
IV. The Education of the Civil Engineer.
V. Characteristics of Civil Engineering as a Profession.
VI. The Outlook for the Civil Engineer.
VII. Concluding Suggestions.

Each chapter will now be described and its contents discussed.

In Chapter I is given a short, concise statement of the development of engineering from the beginning of history down to the present time. While it contains but little that is new to a well-informed engineering reader, the material is presented in such a logical and chronological form as to provide intensely interesting reading for the general lover of good books and for the engineer of literary taste. The gradual segregation of civil engineering (as it is limited today by the highest authorities) from the general engineering of the past is clearly shown, as is also the interdependence of the various lines of engineering.

The author states that "Engineering may perhaps be most briefly and at the same time most broadly described as 'The science and art of construction.' Whoever constructs a thing, whether it be a bridge, a railroad, a steam engine, or a watch, is in the broadest sense an engineer. However, engineering involves not merely manual or mechanical skill, but intelligent application of the laws of nature."

> A science teaches us to "know" and an art to "do." A scientific man studies the reasons for things, investigates the laws of nature, and designs the means of adapting them to the end in view. The merely mechanical routine work of performing the operations necessary for the production or construction of the object or agency desired, is not engineering. A skilled mechanic, therefore, is not an engineer; neither is a skillful roadmaster of a railroad.
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> In a similar manner, the scientist who, in the solitude of his study or laboratory, investigates the laws of nature, and perhaps discovers new ones, is not necessarily an engineer unless he has the capacity of also showing how his discoveries may be made useful, though perhaps he may not himself have the mechanical skill necessary to put them in actual use, or to fashion the tools or instruments necessary for that purpose. An art, therefore, is, or should be founded upon a science, the science of teaching what to do, how to do it and why, while the art develops the specific means of accomplishment.
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> Engineering is therefore, both a science and an art. The engineer must know and must also be able to do. The important thing is the knowing, or the science. The engineer may not actually do a great deal with his hands, but he must at least know how to do it should it be necessary.
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> What we know as the "learned professions" are those in which brain work is necessary and not merely skill. Engineering, therefore, should rightly be considered as one of the learned professions and not merely an art, since it requires for its exercise a knowledge of the laws of nature, and their application.
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> Engineering is clearly both a science and an art. Up to the present time the art involved in the work of engineering has probably been more recognized than a science. The engineer has been considered rather a builder than a scientific man, pursuing an occupation or avocation, rather than a profession.

After discussing still further the question of engineering as a profession and mentioning several well-known definitions of it, including, of course, Tregold's, the author offers the following one of his own:

"Engineering is the science and art of applying, economically, the laws, forces, and materials of nature for the use, convenience, or enjoyment of man."

This is by far the best definition of engineering yet given; and it is certainly a great improvement upon all its predecessors.

After many pages of dissertation concerning what civil engineering is, our author continues thus:

> Having attempted to give some idea of what civil engineering is, it is desirable to call attention to what it is not. The word engineering is often used very vaguely and is made to include occupations which should be designated by another title. The man who runs a locomotive or who superintends a stationary engine plant is frequently termed an engineer, though seldom a civil engineer. Strictly speaking, this designation is a misnomer. Such a man should be termed an engine man, for while it is undoubtedly true that many men of this class have acute common sense and thorough knowledge of the machinery entrusted to their charge, both as regards its construction and operation, so that they may be in fact intellectually and technically superior to many men who claim the title of engineer, yet there should be a distinction made between the man whose business it is to design as well as to construct, who understands the science as well as the art, and the man whose occupation it is simply to superintend the running of a machine or a plant.
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> Attention has been called to the fact that as civilization advances, the various branches of engineering developed, resulting

> in the differentiation of many specialties. It may, however, be fairly claimed that the development of engineering was not a result of the advance of civilization, but the principal cause of it.
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> It will probably be perceived that what we call progress in civilization has been mainly due to the advance in the applications of the laws of nature, that is, to the work of the engineer, and that any improvement in moral standards and ideals follows as a result of these advances.
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> No profession is, therefore, more important for the welfare of the human race than engineering, not even that of medicine, which has done so much for the alleviation of the physical suffering of mankind. None has done more to promote the well-being and to advance the best interests, material and moral, of the human family.
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> The engineer is, therefore, the true civilizer of mankind or the advance agent of civilization. If all he has accomplished in the last few centuries could be wiped out, what would remain of our civilization?

In Chapter II on "Branches of Civil Engineering," Dr. Swain divides civil engineering into the following specialties:

(1) Surveying and Geodesy.
(2) Railroad Engineering.
(3) Highway Engineering.
(4) Hydraulic Engineering.
(5) Sanitary Engineering.
(6) Structural Engineering.
(7) Municipal Engineering.

> To these may be added the consideration of certain branches which involve the relations between engineering and various economical and sociological problems, which are now attracting considerable attention, such as valuation and city planning.

The author then discusses at length each of the specialties, defining its extent and showing how it is related to the other specialties.

Speaking of railroading, he quotes the following striking statement, made long ago by Macauley in his "History of England."

> The chief cause which made the fusion of the different elements of society (in 1695) so imperfect, was the extreme difficulty which our ancestors found in passing from place to place. Of all inventions, the alphabet and the printing press alone excepted, those inventions which abridge distance have done most for the civilization of our species. Every improvement in the means of locomotion benefits mankind morally and intellectually, as well as materially, and not alone facilitates the interchange of the various productions of nature and art, but tends to remove natural and provincial antipathies and to bind together all the branches of the great human family.

This recalls to the reviewer's mind the fact that last year, whilst traveling through China, where he made many addresses to engineering societies and students in technical schools, he stated on several occasions that, had the gap in the railroad line between Hankow and Canton been completed at the time intended, thus bringing the latter city and Peking within forty-eight hours of each other, there never would have occurred the secession of South China from the Republic, and adding the statement that to let the existing division continue indefinitely would be just as disastrous for China, as would have been the permanent separation of the Northern and Southern States at the conclusion of the American Civil War. Judging by what is occurring today, the Chinese are beginning to awaken to a realization of the truth of this claim; and it is sincerely to be hoped that very shortly the existing disturbance in the Orient will come to an end and that there will be once more a reunited Chinese Republic.

Continuing the subject of railroading, Dr. Swain says:

> Notwithstanding the substantial completion of our lines of railroad, they still require the expenditure of almost as much money on new construction, for improvements and enlargements, as at any time in the past. The civil engineer is the man who designs and carries through this work. He must have the vision to see possibilities; he must have the financial acumen to determine whether they are worth while; he must have the power of convincing others, which will enable him to secure the approval of his plans; he must have the executive ability and the power of controlling other men, to enable him to carry them to a successful completion.
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> Not a few of the railroad presidents have come up from the corps of engineers, and if the civil engineer, instead of confining himself to narrow technical details, as he too often does, will study the questions of railroad management and financial policy, he will find abundant opportunity for the exercise of talents of the highest order.

Concluding what he has to say on the subject of "Highway Engineering," Dr. Swain uses these words of warning in respect to the needless expenditure of large sums of money:

> Especially at the present time, when the world is trying to recover from the greatest cataclysm in history, it is necessary to practice economy—individually, municipal and state—to keep our feet on the ground, and to indulge in no schemes of public expenditure that cannot be proved to be self-supporting or fully justified by benefits to be received.

Under the head of "Hydraulic Engineering," speaking of the ultimate exhaustion of our supplies of coal and oil, Dr. Swain remarks:

> What the world will do when that time comes is problematical; perhaps other supplies will be discovered, or other methods of generating power, as, for instance, from the sun or by some chemical means. The patent fact is, however, that fuels are exhaustible and cannot be replaced.
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> On the other hand, every pound of water that falls over a rapid or waterfall generates a power which, if not used, is lost forever; but other pounds of water will continue to fall over that rapid to supply the place of that which has been lost. It may therefore be said that every pound of fuel which is burned is lost forever while every pound of falling water not utilized is lost forever, though other pounds of water take its place. The desirability of developing water power and conserving our fuel supply is, therefore, evident. Such development should be encouraged in every possible way.
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> It is now possible to transmit power by electricity for a distance of some 500 miles from its source. Therefore, though a water power may be located in an inaccessible mountain district, it may be transmitted and utilized a long distance away, or it may be used for electrifying railroads passing through the mountains.
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> The various uses of a river are in a measure interdependent. The development of a water power on a river may be connected with rendering it navigable, with regulating its flow, with the use of the water for irrigation, and for the water supply of cities. The proper use for one of these purposes may be consistent or inconsistent with the proper use for another. The proper regulation of a stream for the development of power requires that the reservoirs, if there are any, should be drawn upon in such a way as to permit an equable flow. The best use for irrigation may require a somewhat different utilization of the reservoirs. All these various uses of water must be understood by the hydraulic engineer, and he must be able to study a large project or carry on a given work in such a way as to permit of the best development.
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> Enough has been said to show conclusively that the field of hydraulic engineering is a most important and extensive one; that it is a clean and interesting branch of the profession; that it requires great ability and a thorough knowledge of hydraulics, structures, materials and hydrology; and that as long as civilization advances and commerce increases, as long as power is used, and as long as our rivers flow down hill, there will be always abundant opportunities for the hydraulic engineer to construct works for the benefit and convenience of man.

Concluding his dissertation on "Structural Engineering," Dr. Swain says:

> It will be seen from this outline that the field of structural engineering is very large and is constantly expanding. It is one of the specialized branches of engineering, and the specialist in it finds opportunities for the application of his ability in connection with all branches of engineering and constructive work.

Under "Municipal Engineering" our author remarks:

> The city engineer should therefore be a man of broad outlook and large experience. His work is very varied. If he needs special advice on any of his problems he calls in consulting engineers who are specialists; but he must have a broad grasp upon all of his problems.
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> The position of city engineer is often not recognized as it should be; politics often governs the selection of the man and he is subject to the vicissitudes of political changes. Hence the position is not generally sought by engineers of eminence. Yet there are notable exceptions; and not infrequently the city engineer is the official least likely to be affected by a change in administration, holding his position continuously, no matter what party is in power.
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> The work of the city engineer deals not only with construction, but also with maintenance. It also has to do with economic questions, such as methods of assessing taxes for improvements, as for streets and sewers, methods of condemning land, etc., and so it contributes to the cultivation of breadth of view on the part of the engineer.

"The work of the city engineer (etc. Copy p. 87).

Under the heading "Valuation of Properties," Dr. Swain says: "This question (etc. Copy p. 88).

This question has become a leading one in the economic discussion of the day and before courts. It is a question of economics

> and justice, as well as of engineering. In this field, engineering comes into contact with accounting, with economics, with law, and with the general question of the relations between the utilities and the public.
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> This work requires the possession of a judicial attitude of mind and of the ability to analyze accounts, and to deal with economic questions of a somewhat intricate nature.

Chapter III on "Qualifications Necessary or Desirable for the Civil Engineer," begins with the following paragraph, which is full of words of wisdom that ought to be heeded by all young civil engineers, whether they be in embryo or fully fledged:

> For the successful practice of Civil Engineering, as of other occupations, specific qualifications of a professional and of a personal kind are requisite, or if not absolutely necessary, at least desirable. Professional qualifications are those qualities or requirements which affect mainly his knowledge, and which, therefore, supply the basis for his intelligent dealing with the problems to be solved. Personal qualifications are those which fit him to apply his knowledge properly, economically, and effectively, and so to accomplish the results which his professional knowledge and skill indicate to be desirable or necessary The two kinds of qualifications do not always go together, and yet their union is necessary for the highest success. An engineer may have great professional ability, yet on account of the lack of some personal quality, such as tact or promptness, may be a miserable failure in certain kinds of work. On the other hand, an engineer possessed of all the personal qualities necessary, but lacking professional knowledge, such as of the properties of the materials to be used, or the laws of nature applicable to the case, may find his plans or his structure a costly failure.
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> It will be abundantly evident, from what has been presented in the last chapter, that engineering is not an abstract science, which can be followed up by a recluse in his study, but an intensely practical affair, indeed, a kind of business. The engineer must be a business man, not a theorist, and must conduct his work on business principles.
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> It is particularly important that the engineer should possess the scientific attitude of mind. By this is meant the attitude that leads him to approach a problem entirely without prejudice, without preconceived ideas, intent only on seeking the truth, the whole truth, and nothing but the truth; and the willingness to accept the truth when found, even if it is unpalatable or may lead to the abandonment of the project on which he is engaged.
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> Mathematics is a somewhat curious subject of study. It is a machine and works with unerring accuracy. Into one end of the machine are put the data, the crank is turned, the machine works and the result comes out with absolute correctness. But this correctness depends entirely upon the data. It is only really correct if the data are correct. Put in correct data and a correct result will be reached; put in incorrect data and the result will be correspondingly incorrect.
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> If the data are either incorrect or incomplete, the most elaborate mathematical analysis may be worthless. Yet the study of abstract mathematics tends to lead the mind away from a proper attention to data; it tends to educate away from common sense. That is the reason why the finest mathematicians sometimes make the poorest engineers. The engineer must look upon mathematics merely as a machine or tool, which, with judgment, common sense, and clear purpose, he uses for the end in view. He must never be mastered or governed by it, but make his own intellect its master.
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> But engineering deals with the facts and problems of actual life, in which data are uncertain, exactness impossible, conditions shifting and variable, and premises generally more or less doubtful. The engineer must perceive the relation of these uncertainties to his problem and the results of his analytical deductions. In studying mathematics, as John Stuart Mill said, the mind must not "go to sleep over mathematical symbols."
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> In other words, mathematics studied in the abstract tends to diminish that most important faculty for the engineer, or for that matter, for any one who deals with the actual problems of life, common sense
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> The engineer must not allow his study of mathematics to become too abstract and must continually perceive the uses and the practical bearings of the science. If he does not do this, but allows the abstract mathematical viewpoint to dominate his mind, he may become a fine mathematician or theorist, but he will probably find himself always occupying subordinate positions, doing the routine work of calculation, or in other words, turning the crank for those who have the greater grasp which enables them to tell him what to do
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> Almost anyone can either do engineereing work or hire it done; but in engineering, as in other things, few can do just the right thing and in the most economical way. It may sound materialistic and unidealistic, but the question of economy properly comes into almost every affair of life, even into charity.
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> It is comparatively easy to build a bridge, although it requires skill, but more important than the question—how to build it—are the questions—where to build it, when to build it, and whether to build it at all.
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> Not only must estimates of cost be made in connection with almost every engineering project, but the study of engineering economics often requires that facts be compared which can only be expressed in incommensurable terms. Elements must be weighed against each other which are entirely different in character.
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> In engineering work it is frequently necessary to make comparisons between things which have to do with our physical well-being and those which have to do with our economic, or even with our moral or spiritual well-being. Although these things are incommensurable, they must be compared and an opinion formed from the comparison.
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> No special directions or specifications can be given with reference to the economic sense which must be possessed by the engineer. It may be called a special sense and involves the use of judgment, and above all things, a well-balanced mind.
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> The economic sense, therefore, is intimately connected with the fourth and last of the professional requirements which have been named as requisite for the engineer.
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> This requirement is, in brief, a sense of proportion, or a proper mental balance.
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> This is an essential in any walk of life, but especially in the case of a man who has to do with the consideration or management of large enterprises. The ability to observe correctly, the faculty of getting all the facts and of knowing when all of the pertinent facts have been collected, the ability to reason from these facts, the possession of conservatism and calmness of mind, the lack of sentiment, the absence of a stubborn persistence in holding to a previously formed opinion in the face of proof of its error, and the faculty of seeing different things in proper proportion and weighing them fairly against each other are all essential to a well balanced mind. An engineer may possess technical knowledge and great mathematical ability, but without balance he ought never to be a leader and his judgment in large matters will be worth little or nothing.
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> Most men learn only by experience, and while experience is the best teacher, it is a very costly one. The advice given by old and experienced men may be most valuable, but it is too often disregarded by the young, who think they know it all and who can only learn by their own mistakes, and so the old continue to warn and to advise and the young continue to disregard and to suffer.
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> The engineer must also have a business sense, remembering that engineering is not simply utilizing the forces of nature for the benefit of man, but utilizing them economically and properly. His work requires financial and business ability combined with a clear insight into the practical relations of things.
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> He must be an organizer and know how large a force is necessary to carry on the work, and how to dispose it to the best advantage and with the greatest economy. He must, therefore, be a student of men and must know how to get along with them smoothly and to get the most work from them.
>
> The engineer not only applies the materials and resources of nature, but he must know how to conserve them.

Concerning personal qualifications Dr. Swain remarks thus:

> In considering the personal qualifications which an engineer should possess it is difficult to make a distinction between those which are particularly necessary for the engineer, and those which are necessary for success in any field of endeavor. Such qualifications as character, promptness, tact, good manners, patience, perseverance, system, power of concentration, self-confidence, respect for others, and many others that could be named, are requisite for the highest success in any field. There are some, however, which, while also requisite to greater or less degree in any field, may be specially mentioned as desirable for the engineer. These are the following:
>
> (1) Judgment.
> (2) Balance.
> (3) A trained mind.
> (4) Experience.
> (5) Initiative.
> (6) Good health.
> (7) Knowledge.

Discussing the subject of "Balance," Dr. Swain says:

> The balanced man does not pursue impractical ideals. He does

not start out by assuming the object at which he wishes to aim. He realizes that he cannot determine upon the aim until he has studied the facts and found out what is practicable.

* * * *

Mental courage, or the ability to face and accept unpalatable conclusions is essential for balance. The balanced man is clam and quiet in speech, not argumentative and not disposed to express his opinions with dogmatism. He realizes always the limitations of his own knowledge and the uncertainties surrounding every problem with which he deals, and he is not afraid to alter his opinion when new facts which justify it come to his attention.

In respect to the subject of "A Trained Mind," our author remarks:

> The man with a trained mind is possessed of a machine which he can direct to any problem that comes before him. When directed to such a problem his mind will know how to attack it, where to get the facts that are requisite, when and where to get the advice and assistance of other men, and will be able to arrive at correct conclusions. The man with a trained mind is a safer man, even in dealing with a problem that he has never thought of before, than the expert in that subject if without a trained mind.

Concerning "Initiative," Dr. Swain truly says:

> The engineer must have initiative. He is often called upon to make a quick decision, to meet a new problem, or to do something that he has never done before. He must be resourceful. He must not depend too much on books, but must realize the limitations and even the dangers of mere book learning.

Chapter IV on "Education of the Engineer" is replete with knowledge and sound sense; and to appreciate it adequately one should read it in toto. It is well worthy of perusal by any engineer who takes interest in technical education, every professor of engineering, every engineering student, and every young man who contemplates a technical course. From among its salient gems of thought the following are selected:

> The college cannot make a man an engineer, but it can afford the opportunity to gain that knowledge and discipline which will enable him to advance in his profession much more rapidly than he could without it.
>
> * * * *
>
> The true object of education cannot be attained without effort. When the work of a student is easy for him, it should be changed. The easy path does not give discipline; it is the steep and rugged path which requires the effort that develops the powers of mind and body.
>
> * * * *
>
> The institute is a place for men to work, not for boys to play.
>
> * * * *
>
> Engineering is a profession, and the students of engineering are professional students. If they take a college technical course, they should be imbued with the professional spirit and should not be permitted to indulge themselves in the lax methods so common among college students who are candidates for the A. B. degree.
>
> * * * *
>
> It is not a college course which makes a man, but only what power, discipline and inspiration he gets out of it. And many a man with no college course at all is far superior in every way to many college graduates.

In this chapter the author gives a most interesting dissertation on how best an engineering student can obtain both technical and cultural instruction, weighing the pros and cons for each suggested method; but the reviewer would state that, in his opinion, the best method is to mix the two throughout the entire curriculum, and to make the duration thereof five or, preferably, six years instead of the standard four years.

As Dr. Swain notes:

> Abraham Flexner, in his volume, "The American College," says, "Now as a matter of fact, the college does not even rise to the accepted standards of the commercial world, to whose demoralizing influence its scholarly ideals are occasionally alleged to have succumbed. For college standards of success are actually below those that prevail outside. A youth may win his degree on a showing that would in an office cost him his desk." And again, "the important thing is to realize that the American college is deficient, and unnecessarily deficient, alike in earnestness and in pedagogical intelligence; that in consequence our college students are, and for the most part, emerge, flighty, superficial and immature, lacking as a class concentration, seriousness and thoroughness."

Similar scathing remarks concerning college curricula and college students are quoted from the writings of Dr. Henry S. Pritchett, Pres. Jacob G. Schurman, Prof. Charles M. Galey, Prof. W. G. Sumner, and Prof. Charles H. Grandgent.

From such evidence and his own experience Dr. Swain draws the conclusion that—

> The "thorough training" which is so often claimed, by educators, to have been obtained by college and engineering graduates, is a fallacy. A few men get it, all have the opportunity to get it, but the majority do not get it. It depends on the student. The diploma is no guarantee that he has it.

Then the author proceeds to say:

> There is much misapprehension with regard to education and its aims. The word "education" means, by derivation, drawing or leading out; that is, it should draw out or develop the inherent powers of the man. By many, however, it seems to be considered to mean to put in. The teacher is supposed to put knowledge into the minds of the students, and the student's work is often gauged by the amount which he can retain or remember. Such education is of little value.

Next follows a dissertation on "Selective Courses" that is adverse thereto. The reviewer for many years has contended that not one student in a thousand has his judgment sufficiently developed to enable him to select the best course of study that he needs to fit him for an engineering career. The selections usually made by college students are "to laugh"; and the custom of permitting them to determine what instruction they shall receive is outrageously absurd.

Concerning the subject of "Culture," Dr. Swain says:

> The aim of the college course is frequently said to be "culture." If I may define culture, I may admit that it should be the aim, but if the word means only an external smoothness and roundness of outline without regard to intrinsic qualities, it is a sham. Sumner speaks of a kind of culture which he says might be called sapolio culture "because it consists of putting a high polish on plated ware." If I may define culture as a system of training which brings into intelligent activity all the best powers of the mind and of the body, which teaches how to study, and which develops in the student the power of attacking a new subject or a new problem, I would admit this sort of culture to be the aim of education; but this is discipline and not what is usually termed culture.
>
> Professor Baynes said, "The true end of all higher education is not so much as to fill the mind as to quicken and train its power, not so much as to impart knowledge as to awaken thought."

Concerning "Outside Activities," Dr. Swain has this to say:

> Too many young men in college allow the college life and the outside activities—social, athletic, and others—to become the main thing, to the great detriment of the mental discipline and the habits that are more important.

A few days ago, at a Commencement reunion, the reviewer took part in a lengthy and animated discussion on the subject of college athletics and intercollegiate contests, during the course of which he remarked that athletics judiciously laid out and administered ought to be a blessing, but that intercollegiate contests, at least for technical institutions, are an unmitigated curse. They may be appropriate enough for those colleges where young men go mainly to obtain polish, or for pleasure, irrespective of how much or how little they actually learn; but there is no time for such nonsense in a first-class technical school, where the students are (or should be) men—not boys—and where the objects of the instruction are serious—not frivolous.

At the conference before mentioned, the reviewer remarked: "Athletics does not consist in having two score men struggle for two hours to the limit of their resources and five hundred men sit on benches and applaud."

In a technical school every man should take plenty of physical exercise, in order to keep him in good bodily condition; and, to that end, ample provision should be made for games in which many can compete, such as tennis, handball, basket-ball, la pelota, Rugby foot-ball, swimming, footracing, boxing, fencing, single-stick, and a certain amount of base-ball. Trophies should be offered for success in competitions in such games, but the contestants should be limited to the students of the school.

The spending of a certain amount of time on such athletics should be made obligatory on each student, so as to keep him physically fit; but an excessive devotion to sports should be discouraged.

It is sad to have to confess that the presidents and faculties of some technical schools, in order to secure students for their institutions, are forced to cater to the popular demand for sports by encouraging intercollegiate contests, although they well know at heart that these tend to lower the standing of any technical school by taking time for play that should be spent on work. In the reviewer's opinion, it is not honest treatment of parents and guardians to permit their sons and wards to travel around the country on ball teams sometimes more than half way across the continent.

But to return to Dr. Swain's views on engineering education—speaking again of the elective system, he says:

> The elective system had its origin in the perception of the fundamental truth that men are not equal and that all should not be out

through the same mill. To require the same program of every man is obviously wrong. But in correcting this in the unrestricted, or almost unrestricted, elective system, greater wrongs were introduced.

* * * *

The writer believes that the best balance will be by a course almost entirely prescribed, but allowing the student to choose among a number of such courses.

It must never be forgotten, however, that more depends upon how a subject is taught than upon the subject itself, and that the greatest discipline may come from a subject supposed the least capable of it, if it has the right teacher.

The education of the engineer is never finished. He must be a student all his life, like the lawyer or the physician.

Dr. Sawin sanely remarks:

The education of the engineer is never finished. He must be a student all his life, like the physician or lawyer.

Also:

Applied science is a constant state of flux. It is most important, therefore, that the engineering student should learn How to Study. The college graduate who cannot by himself pursue farther a subject that he has begun, or take up an entirely new subject and master it alone, has largely failed in his education. It is not necessary to teach everything in college. Yet strangely enough little attention is given to training students how to study. It seems to be assumed that because they study, they know how to study. It might as well be assumed that because they can sing, they know how to sing corectly.

* * * *

Our college and preparatory school programs are crowded with subjects that are no doubt of interest and importance, but that had better be left for the student to study by himself, confining the school work—limited in time as it is—to the teaching of fundamentals, to giving the student mental discipline, high aims, mental vision and perspective, mental courage and the power to study by himself.

Chapter IV concludes with the following important advice, which every student should "read, mark, learn, and inwardly digest."

To the great majority of young men who wish to follow a career in engineering my advice would be this: Enter an engineering school as soon as you are prepared, and get the habit of work at once; and not only the habit of work, but train yourself to work effectively. Hard work will not help you much if it is ineffective and does not lead to results. Perseverance is not a virtue if misdirected toward unworthy aims, or toward impossible aims, no matter how good in the abstract.

Broaden yourself as much as possible. Acquaint yourself with the great men who have gone before, learn what they did and said and thought, and relate all this to your own experience and aims. Read the classics in the best translations you can find. Learn to use the English language well and to speak in public without embarrassment. Extend your technical education over more than four years if you can do so profitably, but not too long, for too much school education is as bad as too little, and probably worse. Your real education will come later, any way.

To young men who enter college with no definite aim, my advice would be: No matter what career you may decide to follow, study the science upon which engineering is based, and as much of engineering as you can consistently get in your college course. These things will be useful to you in any career—more useful than many so-called cultural subjects. Select courses that will call forth your most serious effort, not those that are easy for you. Do not aim for culture, whatever you may understand that to mean, but for training.

Acquaint yourself with the principal fields of human thought, and learn thoroughly the fundamental principles of those you select. Do not go too deeply into any one, but study the fundamentals thoroughly. You cannot become an expert or a specialist in four years. If you try to become an expert in college you will more likely turn out a sham or a narrow bigot. If you aim for culture, you will be likely to turn out a conceited ass; if you aim for wisdom you will be likely to turn out a pedant. If you work hard, take advantage of your opportunities, follow good advice, culture and wisdom will come of themselves in due time, if they are meant for you. Select as your guides men who are broad-minded and tolerant, rather than those who are dogmatic and mentally arrogant. Give little time to controversial subjects in which your teacher may hold views very different from those held by equally good authorities elsewhere, and in which your own view—whether based on prejudice or not—cannot be proved either right or wrong; but rather study subjects in which, while there is room for independent thought, if you are wrong you can be shown to be wrong, and the reasons stated. Train your mind to be a reliable, logical instrument which you can turn upon any subject and be sure of reasoning correctly, leaving controversial subjects for later study, when you will have experience to give you the data. Learn to have respect for those who have not had the opportunity for a college education, and realize that many such men are making of themselves more than you will ever make of yourself. Above all, learn intellectual modesty even while sure of your ground, and remember that when you graduate your education will have been only begun.

The following short quotations from "Characteristics of Civil Engineering as a Profession," dealt with in a masterly manner in Chapter V, should prove of deep interest to every engineer:

First among the attractions of Civil Engineering may be placed the opportunity that it offers of doing constructive and enduring work. The second attraction of engineering is that it tends to train and develop character.

* * * *

Mathematics is but one of the tools he uses; the others are judgment, experience, observation, knowledge of the properties of materials, and so on.

* * * *

Engineering also trains habits of logical thought, though perhaps the law may be superior and other vocations equal in this respect. Engineering has the advantage over many other subjects that, while it offers ample opportunity for the use of judgment, and while many things in it may be largely matters of opinion, it deals mainly with matters in which some degree of demonstration is possible. To deal entirely with matters that are certain, as we do in mathematics (the data being assumed) does not necessarily develop the power of logical thinking, but more often merely the skillful use of the machine. Neither does the study of subjects which are much involved in doubt, in which authorities differ widely, and in which experiment and demonstration are difficult or impossible.

* * * *

By its combination of the practical and the scientific of business, administration and the direction of men, engineering may serve to develop a breadth of view which is of great benefit. Many engineers, however, devote themselves so closely to technical details that they lose this advantage; but that is the fault of the individual and not of the profession as such.

* * * *

One of the greatest attractions of an engineering training is the advantage that it gives, and the opportunities that it affords, in the various lines of business. We live in an age of engineering, of power, of applied science. Wars are decided now by engineers, not by knights in single combat. Every industry depends upon the engineer.

* * * *

Of course, in regard to ultimate success, all depends upon the individual. A man who wills to success cannot be kept under. But there is no question in the writer's mind that a proper engineering training is one of the surest roads leading to a successful and useful life.

* * * *

Some engineers complain that their profession has not the standing of the law and medicine in the public estimation, and that the engineer is not as highly respected or as influential as the lawyer. This is certainly untrue, as a general statement. It is a question of the individual. The writer is sure that leading engineers have quite as high a standing as any other members of the community. There are, of course, engineers of low standing and low merit; but there are many more lawyers and doctors who are considered beneath contempt.

* * * *

The engineer is becoming more and more appreciated. He is being called in as an adviser in economic matters, as a witness in cases before the courts, as a member of public commissions, as an arbitrator, and the popular estimation in which he is held is increasing steadily. There is no reason why the highest offices and the greatest distinction should not be within his reach if he will not insist on staying within his shell. He is being daily more and more recognized as the kind of man competent to form a clear, unbiased and independent judgment on important business matters.

* * * *

All the above points to the necessity of a broad training for the engineer, and it shows that if capable men enter the profession they will find in it a field for their activities which has almost unlimited possibilities.

There is one statement in this chapter to which the reviewer begs to take exception, viz: "You cannot experiment scientifically in economics or history." In respect to the latter, the statement is correct, but in regard to the former the reviewer claims that the four years' experimental work which he did in making the ten studies of major economic problems in bridge designing, leading up to his late-issued treatise, "Economics of Bridgework," was truly scientific, although of an eminently practical character.

Concerning "The Outlook for the Civil Engineer," treated in Chapter VI, the following interesting selections are quoted:

It has beeen the testimony of practically all Americans who had charge of important departments in the great war that the men who had had a technical training made the best showing. Secretary Weeks is reported to have said recently, regarding the War

Department, "The records of the department show that of the officers of our armies who served overseas the best results were shown by those who had technical training in addition to their military education.

* * * *

The day of the engineer is approaching, not only the civil engineer, but of the engineer in any branch of the profession. The time is coming, and coming rapidly, when it will be generally recognized that the man who can intelligently control and use the forces and materials of nature for the convenience of man is the one who can be depended upon to direct the largest undertakings, and who is perhaps the largest factor in national progress and prosperity.

Mankind has passed through various "ages." The present age is the **age of power.** Almost every human activity, even farming, depends upon the development and application of power. The development and use of power is the function of the engineer—mechanical, electrical and civil—so that the age of power, now only in its beginnings, must more and more require and recognize the engineer.

Moreover, war is now more a matter of engineering than of anything else. The great war was a conflict of engineers. No longer do knights in polished armor decide by individual prowess the fate of nations, but wars are won by the side that can best use and direct the forces of nature—unfortunately not for the benefit of man—but for his destruction.

* * * *

Our universities should not ignore the handwriting on the wall, and should realize the necessity of filling the great needs of the future in applied science. They must overcome the prejudice in favor of a so-called "culture" which is merely a superficial veneer, without thoroughness or discipline, while doing all they can to promote true culture, combined with discipline, and to bring out the best and highest that is in each student. On the other hand, students of engineering must broaden themselves beyond the narrow limits of their professional studies, and qualify themselves to deal with the great problems of the day, to use the mother tongue correctly, to gain acquaintance with other languages and literatures, and with the thoughts and deeds of great men.

Comparisons are dangerous, and often unprofitable and merely provocative of discontent. The main points to be kept in mind are that a man's success depends mainly upon himself; that money is not the true measure of success; and that civil engineering is a vocation that is healthy, free from many of the worries that harass the lawyer, physician, or business man, and which offers abundant opportunity for creative effort, and for constructing works that conduce each day to the comfort and convenience, and supply the necessities, of great numbers of our fellow men.

Among the numerous "Concluding Suggestions" given in Chapter VII, the following are the most interesting and important:

Having determined upon civil engineering as a career, train yourself by practicing the qualities that will make you successful. Read the biographies of engineers and the history of engineering, and learn the difficulties that have beset engineers and the manner in which they have been surmounted. Above all, observe the qualities—of mind, body and character—which are requisite, and develop them by daily exercise.

Remember that engineering is practical, not abstract, and is more common-sense than anything else. Do not let anything train the common-sense out of you. * * * Train yourself in estimating distances and quantities, and to measure distance by pacing. If you see a big boulder in the field, try to estimate what it weighs; then measure it approximately and see how near you came.

* * * *

Remember that engineering is a science, and that to succeed in it you must master the fundamental principles of chemistry, physics, mathematics and mechanics, and the properties of materials. If you cannot do this, you may be a good mechanic, or you may even be a good administrator or business man, but you will not be an engineer.

Learn, above all things, whether you go to college or not, how to study, so that you can take up a new subject and master it yourself. You will very likely be helped in doing this by the writer's pamphlet, "How to Study," published by McGraw, Hill Book Co., which you should read and re-read until you have absorbed its atmosphere.

* * * *

Do not get the habit of seeking the easy way by evading difficulties, but accustom yoursef to surmount them. This does not mean that you shoud make difficulties, or pursue complicated or abstruse methods where an easy or obvious one will give the same result. This is often done in mathematics and is vicious. Where an easy way will lead to the result, it should of course be chosen; for there is abundant opportunities to cope with difficulties without creating them.

* * * *

To make one suggestion regarding personal habits, the writer strongly advises young men in college or in engineering not to smoke during working hours. The writer is a smoker, but he did not smoke at all until after he was thirty-five. Many successfu engineers are great smokers and many do not smoke at all. If you must smoke, do it at home in the evening. During your working hours your time and your best efforts belong to your employer and your efficiency will be diminished if you smoke. Some engineering offices and industrial establishments do not allow smoking during working hours, and that is right. The same principles are true about work in college, and the student will do best for himself by not smoking at all.

* * * *

When you graduate from college and look for a job, be willing to begin at the bottom, at small wages, and to do anything that is useful. Have no high-flown ideas about what is dignified. All labor is dignified; it is loafing that is undignified. Do not think that because you have a diploma you can begin at or near the top.

* * * *

The schools sometimes foster the idea that they can prepare young men to begin as "managers" or administrators, omitting the routine of experience. It is a fallacy. It cannot be done. There are routine and drudgery in every occupation. You must be able to perform these cheerfully, uncomplainingly and well.

The young man taking a job should be willing to do anything, and when he has finished one piece of work, should ask for another, not wait until it is brought to him; and he should not watch the clock. The writer once sent two young men from the same class to work in the same office. One strove to do all he could; when one job was finished he asked for another, and he stayed after hours if by doing so he could help his employer. He rose to the highest position in the concern. The other had his eye on the clock, stopped promptly when the bell rang, and when he finished one job read a newspaper until he was told to do something else. When the first man had nearly reached the highest round of the ladder, the second was not far beyond where he started.

As a conclusion to the book, Dr. Swain quotes in full the short "Code of Ethics" of the American Society of Civil Engineers. To the reviewer this code has always seemed disappointing, for it is far too meager to be of actual use in an emergency. Some thing much more detailed would be greatly preferable. It is too suggestive of the old saw, "Be good and you'll be happy." However, it is the best that we engineers possess; hence we should try to content ourselves with it by recalling Dr. Swain's remark that "It is well to have such a code, and yet, when all is said and done, if a man has not the principles of morality in his soul, such a code will not hold him up to the highest moral standard, though it may give ground for punishment or for disbarring him from practice, if he violates its canons."

Whatever may be the ultimate fate of this little treatise, it undoubtedly will prove a lasting monument to the genius of Dr. Swain and to his reputation as a man, an educator, and an engineer.

Properly handled, the book is capable of accomplishing immense benefit for engineering students and young engineers, and, consequently, also for our beloved profession—but, alas! the chance of its so doing is small—not because of any shortcoming on the part of either the author or the publisher, but by reason of the utter indifference of the average technical instructor to the true welfare of his pupils in respect to character, efficiency, and mental development, and because most engineering students greatly prefer looking at a ball game rather than studying instructive books and endeavoring seriously to prepare themselves to become worthy members of the greatest of all the learned professions.

Concerning this matter the reviewer speaks from sad experience; for more than a decade ago he compiled a book of addresses, dealing with the welfare and professional success of technical students and young engineers; and his firm placed it upon the market at a price considerably below the cost of production and distribution, relying upon American engineering instructors to see that it was read and studied by their pupils. For a while it was quite a success; and many reports showed that it was the means of effecting much good; but, after some eight thousand copies had been distributed, the book was forced out of print by the general apathy of our technical instructors.

As a concluding word to this rather lengthy review, the reviewer desires to express the sincere hope that Dr. Swain's new masterpiece of altruistic literature will meet with a better fate than that of the larger work just mentioned that was written for a like purpose.

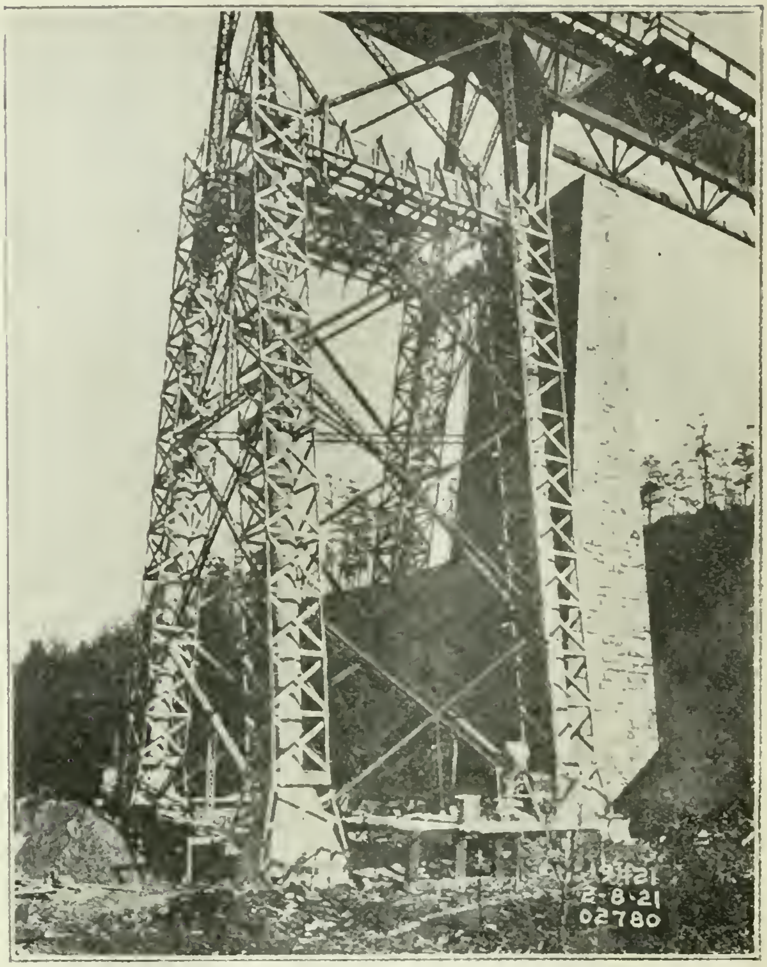
34,000 Miles of Electric Railway in U. S.—The total mileage of electric railways in the United States is approximately 34,000.

Methods of Constructing Railway Fills and Caring for Structures During Filling

Useful suggestions on the construction of railway fills were given by the Committee on Roadway of the American Railway Engineering Association in its report presented at the last annual convention of the Association. The notes following are taken from the report.

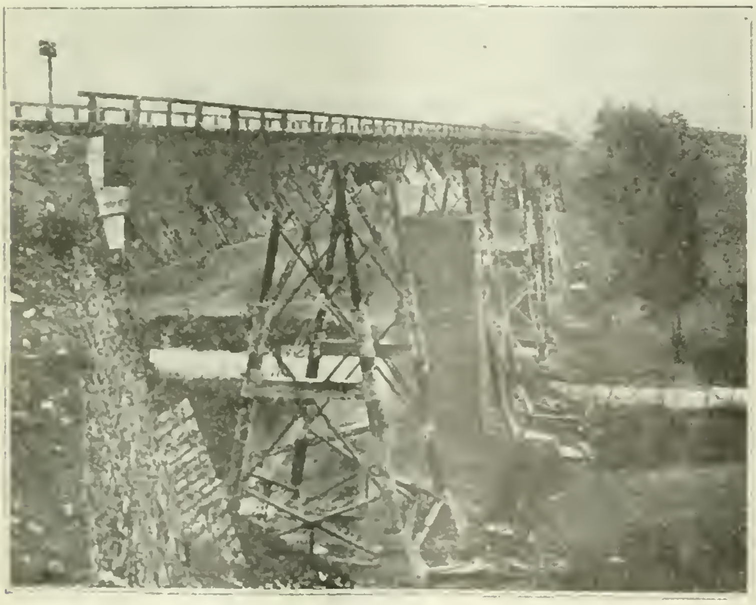
Before starting to construct a fill see if there are any springs in the area to be covered, and if so, build concrete boxes over them and pipe the water beyond the limit of the new fill, where rock is available and fall is sufficient. French drains may be substituted for the pipe. In certain sections of the country where trestles are to be filled in marsh land, it is frequently found advantageous to lay a grillage consisting of a double layer of small tree trunks; the layers being at right angles to each other. In the absence of tree trunks old bridge timber or sawmill slabs can be substituted. This grillage assists in preventing unequal settlement and excessive subsidence.

Preparatory Work on Structures.—With wooden trestles, before starting new fill, the trestle must be carefully gone over and put in shape to stand the stresses incident to filling. This is very important, because if it is not done and the trestle gets out of surface or line, or both, it is almost impossible to get it back to proper shape. While this item does not amount to much in a 10 or 12 ft. trestle, when dealing with a trestle over 20 ft. high, it is important. If this preliminary work is properly done, it is almost always possible to keep the structure in good line, although, of course, the entire foundation may settle and cause a settlement in the surface of the trestle. Such a settlement, however, is generally not a serious difficulty, as long as the line is good. Ordinarily, a foundation which is good enough to support a standard frame trestle will be found to give very little trouble during filling if a bearing 4 ft. wide is provided the full length of each sill. In this connection, special attention should be given to removing all soft timber from bottom of posts, from sills, and from bottom bracing, and sometimes additional posts. It is better to spend a little money preparing a trestle to stand filling than to take a chance of having to spend much more during the progress of the work. It has been found to be a fairly good rule to work by that in a trestle 20 ft. high the blocking sills, bottom of posts, and braces, should be in condition to run two years without repairs, and in a trestle 35 ft. high or over, three years, before the structure should be considered in good enough condition to stand filling.



Forming to Hold Molds for Pouring Concrete Around High Tower Columns Stiffening the Columns to Resist Deformation During Filling.

In the case of iron and steel viaducts which are usually of greater height than wooden structures, precautions must be taken to prevent distortion of the columns. This can be accomplished by encasing the columns in reinforced concrete up to a point within 20 ft. of base of rail, or where there is no danger from fire satisfactory results have been obtained by the erection of intermediate wooden bents at suitable intervals in order to reduce the load upon the towers.



Concrete Stiffened Columns After Forms Have Been Removed; Also V-Shaped Wooden Shields to Spread Filling Materials When Center Dump Cars Are Used.

As the filling of the viaduct proceeds, all bracing, both longitudinal and transverse, should be cut loose from the bents as the fill reaches the connection points, for this bracing transfers a great deal of load to the bents, which increases the settlement and has a tendency to work the viaduct out of line. Vertical bracing need only be cut loose at the upper connecting points.

General Methods of Filling.—There are two methods in general use for filling bridge openings:

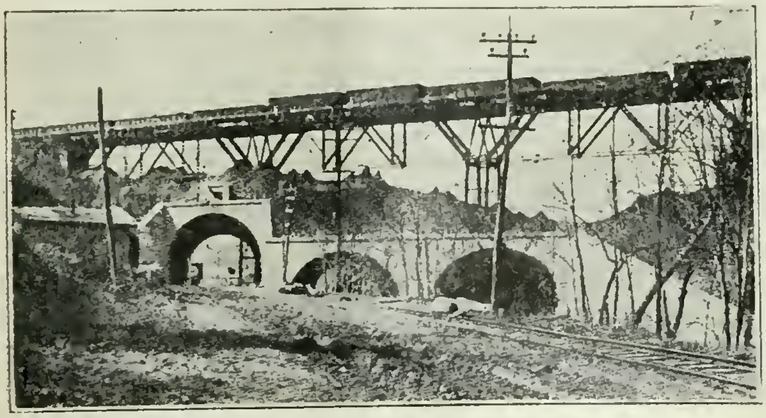
1. By use of side or center dump cars, or both.
2. By teams from adjacent cuts and borrow pits.
3. By grab buckets swung from cable way.

In lesser degree:

4. By endless belt conveyor.
5. By dumping from cars and leveling by sluicing.
6. By hydraulic excavation and leveling by sluicing.

Where foundation is good, and in case of low trestles, where it is not good, fills can be made by dumping directly from the structure in conjunction with two 16-yd. air dump cars for jobs of approximately 5,000 cu. yd. or less, and by steam shovel and air dump cars for jobs of over 5,000 cu. yd., though this dividing line is by no means fixed, as it depends on the haul, the depth of cuts from which material is available, and the relative need for ditching the cuts in the vicinity of the structure. The double benefit derived from the use of a ditcher often justifies a greater total expenditure than would be involved in the use of a steam shovel.

Before dumping from a trestle, wooden guard timbers should be removed and plank about 2 in. by 2 in. should be spiked on top of ties, close by rail, to prevent ties from bunching. This applies to side dumping. When center dumping is employed, the same method may be followed with the addition of cutting out alternate ties between the inside line of the stringers.



Views of Filling Operations Involving Heavy Concrete Construction; Arch Over Highway and Trolley, and Two Arches Over Stream. Note the High Drop of Filling Material. Concrete Was Protected by Cushion of 1 or 2-Man Stone Over Barrel of Each Arch.

When dumping large rocks, care should be taken not to damage essential members of the structure. It is sometimes advantageous to install inverted "V" shaped wooden shields with comb located under the center line of track. This accomplishes a dual purpose: first, it affords protection to members which may otherwise be damaged by heavy filling material from a high drop; secondly, this approximates to the side dump method which results in less disturbance to the structure. The shields must be removed when the filling has progressed so far that the dirt will not fall free of the shield.

When filling high trestles where foundation is very bad and appears liable to give trouble due to settlement, and traffic may be sufficiently heavy to justify it, it may be advisable to build temporary trestles on each side of the main trestle, say from one-third to one-half the height of main trestle, and located so that material dumped from same will spread to cover the area of the completed fill. The use of grab buckets from a cable way or use of endless belt conveyor may be employed to advantage in making fills of this character. Then by dumping simultaneously from all three trestles, or dumping simultaneously from main trestle and cable ways, the settlement may be reduced and kept fairly uniform.

It is often advisable to haul filling material further, in order to obtain a better grade of material to stabilize the fill and reduce cost of future maintenance.

Sufficient material should be deposited in the fill to allow for shrinkage of embankment and subsidence of foundation. Fills made adjacent to and subject to erosion by rivers may be made more compact and repellent to water action by having the dirt spread by teams in layers over the entire area to be covered.

It is considered good practice when filling trestles of over approximately 25 ft. in height to install a small pump, if there is water available at the opening, and run a pipe line underneath the ties through the center of the trestle, having valves at intervals so that the trough formed by dumping on both sides of the trestle, or the central core when center dump cars are used, is kept continually wet. In this way settlement occurs gradually as the filling is deposited, with the result that the filled trestle is not carried so badly out of line and surface, but also when the fill is completed there is a solid puddle core from the bottom to the top to carry the weight of trains.

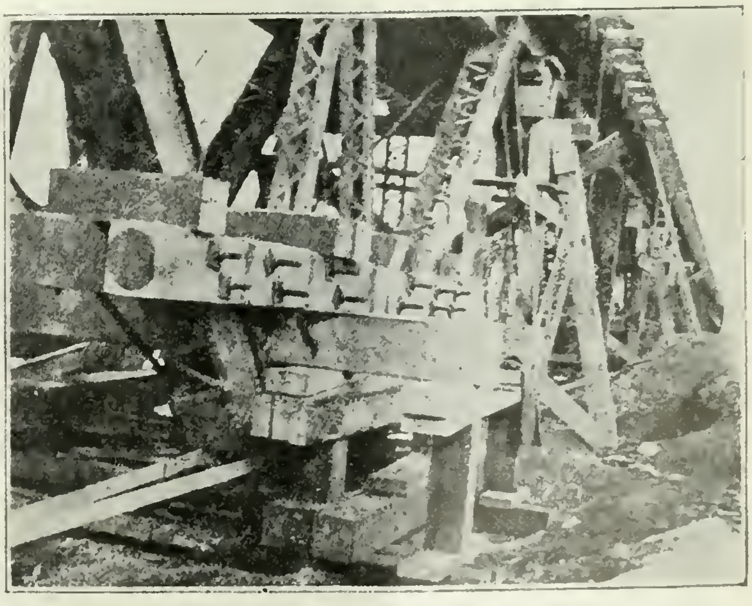
Immediately after the completion of the filling of low trestles, the stringers should be removed, but in cases of high trestles, the stringers should not be removed until the fill has settled about all it will without the load of trains; except that, if trestle has become so badly out of line and surface that it cannot be resurfaced and relined, it is better to remove the stringers at once and put the load on the green fill, even if this requires considerable watching and resurfacing of track for some time.

Care should be taken to avoid the formation of a trough which will hold water when removing stringers. This may be done by filling openings left by stringers with a good grade of clay, and tamping and crowning same before applying ballast.

On account of its cheapness and ease of handling, track should be ballasted on engine ashes until new fill has entirely stopped settling.

Where engine ashes or commercial dirt is used for making fill, great care should be taken that the fill does not catch fire. When engine ashes are collected from water pits the fire hazard is very greatly reduced, but where cars are loaded from hot ash pits and the fires are not quenched by the ash pit shovelers, the cars should be run under the water plug in order that the live coals may be deadened. In handling commercial dirt, yard scrapings, shop cleanings, and filling of that general character, all paper, sticks, planks, greasy rags, oily waste, etc., should be removed during the unloading process, for if allowed to remain, spontaneous combustion will probably set in with disastrous results; particularly is this the case where live coals in the engine ashes become a part of the fill. On a large job of this kind it is always well to have a good sized force pump installed with sufficient fire hose to overcome fire, which may start in the fill when least expected.

It is recommended that in making fills of great height, or when unusual conditions are anticipated, that an inspector with full authority be kept continuously on the work.



Saddle on Heavy Timber Grillage to Carry Ends of Deck Trusses After Fire in Fill Had Destroyed Supporting High Tower Columns.

Hydraulic Filling.—Water is diverted from the most convenient mountain stream and carried along the mountain side parallel with the line of track and usually about 200 ft. above same, from which it is taken for use in the hydraulic "monitor or giant" employed in this work. The jet used is from 3 to 4 in. in diameter, depending upon the amount of water available. The material is carried to the trestle in ordinary rectangular box flumes and the discharge outlet is varied from time to time to meet the requirements. The building of the levee is a special feature. It is usually constructed of alternate layers of earth and straw or hay, tough marsh grass is suited best for this purpose. The material is spaded from the inside and the hay is distributed by a man walking along the dike and shaking same down neatly. The next layer of earth compacts the hay and while this might appear to be quite porous, it is in fact very quickly puddled by the action of the water. The embankment is usually constructed to within 3 or 4 ft. of its finished elevation, and is then completed by train. Banks constructed in this manner are remarkably solid and subsidence is unusual other than that arising in some cases from the compression of the original soil on which it rests; also the hay or straw on the levee has the advantage of protecting the newly made bank not only during the first year but subsequently as the seeds germinate and form a sod. The cost of the process varies with the local conditions, but this method is very satisfactory in that there is no interruption to traffic by work trains during the greater part of the work. This method has been largely used on the Northern Pacific Ry.

Reclaiming Copper Smelter Slag for Track Ballast

Copper smelter slag used to ballast track on the Southern Pacific Lines has proved highly satisfactory, according to reports from various sources. It has easy riding qualities, does not hold moisture, and no vegetation will grow in it. How this ballasting slag is obtained from the slag banks at the plant of the American Smelting & Refining Co., 4 miles northeast of El Paso, Tex., is described in American Ditcher Scoopings, from which the matter following is taken.

The slag represents the skimmings from the copper furnace. The slag bank is 60 ft. high and more than 600 ft. long and the material is so hard that it requires blasting. It weighs 3,600 lb. to the cubic yard.

This material is loaded into cars for shipment out on line by a railroad ditcher which works on a spur track running along the base of the bank and loads into cars on a parallel track. The loading spur is 600 ft. long. The cars used are 100,000-lb. capacity ballast cars with center and side dump bottom doors, equipped with small plows to clear the rails of material being unloaded.

Blasting operations require the constant services of from two to three sets of hand drills, 4 men being used to the drill. Hand drills are used on account of the peculiar nature of the material, it having been found that the vibration of air and steam drills causes caving. To avoid this with the hand method the holes are kept lined with wet clay throughout their entire depth, the clay being inserted at frequent intervals as the drilling progresses. When the hole is completed to a depth of 18 or 20 ft. it is sprung with dynamite and loaded with blasting powder.

The method of drilling and firing the "shots" is as follows: First, holes are drilled about 12 ft. from the bottom of the bank, or, in other words, 12 ft. above the track level. These holes are charged and fired and the ditcher loads the material thus loosened. This is called shooting the "toe" out of the bank. If the ditcher encounters any hard spots while loading, more holes are put down and the hard spots broken up.

After the "toe" has been loosened up the drill gang moves up the bank 20 or 30 ft. and puts down more holes. By the time these are ready to blow the ditcher has all the material from the "toe" loaded out. After the second lot of holes have been fired the drillers move up to the top of the bank and put down a row of holes 20 to 25 ft. deep and 10 to 15 ft. apart. When this last blast has been fired and all the material loaded out the track is moved over to within 2 or 3 ft. of the new face and the operation repeated.

The effect of the blasting operation is to crumble the slag into small pieces suitable for use as ballast without any further crushing. The "shot" also puts the blasted material right alongside the ditcher track, in fact, sometimes it even covers the track. The material is then loaded into ballast cars by the railroad ditcher. The cars hold an average of 32 yards of this material, and as many as 18 cars have been loaded in a single day.

It has never been possible to work a full day, as there is always some delay waiting for the switch engine to pull out the loaded cars, or bring in empties. The coal car is kept on the far end of the string of empties and is pulled back each night within reach of the ditcher, as the track on which the cars stand is 300 ft. longer than the ditcher track and cars are pulled down by the ditcher as needed. This track arrangement was necessitated by the nature of the slag pile, the bank being higher and more slag being available near the end of the pile.

The water car stands on a third track opposite the ditcher and loading tracks, and water is piped across to within reach of the ditcher's siphon hose.

This arrangement was worked out to give more room at the end of the loading track. The tank car is filled every 10 days and about 1,400 lbs. of coal is used a day.

Four men are used in the pit in addition to the ditcher operator and his fireman, to close dumps on cars, do track work and rake down loose slag.

The outfit works 8 hours a day and loads out an average daily yardage of 450 yds. The labor cost of getting out the ballast for one day, Dec. 17, 1921, from 7 a. m. to 6 p. m., was as follows:

PIT EXPENSE.

Force Employed	No. hrs.	Wages.	Per day.
Engineer (1)	10	$160.20	$ 7.70
Fireman (1)	11	90.00	4.75
Watchman (1)	12	90.00	2.91
Blacksmiths (1)	8	40c hr.	3.20
Drillers (10)	8	44c hr.	35.20
Powderman (1)	8	58c hr.	4.64
Laborers (4)	8	28c hr.	8.96
Total force expense			$67.36

SUPPLIES.

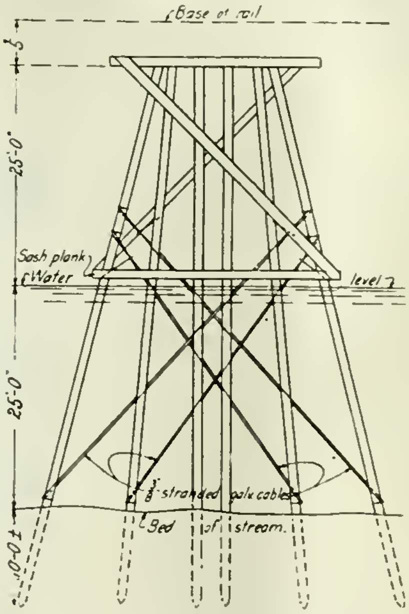
Kind Used.	Quarts.	Pints.
Valve oil		1
Engine oil		1
Powder	300 lb.	
Dynamite	25 lb.	
Caps and fuse	6 and 6	
Coal	1,500 lb.	

DELAYS.

Description.	Hrs.	Mins.	Remarks.
Waiting for cars	1	30	
Other delays		30	3 tanks of water.
Total delays	2		

Bracing Trestle Bents in Deep Water

The Louisville division bridge forces of the Pennsylvania System successfully solved a problem of bracing falsework under water at Bridge No. 185 on the Madison branch in 1915, writes D. B. Johnston in The Railway Maintenance Engineer. The sketch shows the bracing used above and below water on each of the bents.



Method of Bracing Bent.

About 70 ft. of 3/8-in. messenger cable for each bent, secured from the telegraph department, was looped and stapled around each of four piles in each bent at such a distance from the tip as would bring it about to the bed of the stream. The two free ends of each cable were lightly stapled alongside of the pile and the cable driven with it. When the driving was completed the wires were placed by crossing them between each pair of piles, drawing them up taut with the derrick car and making them fast above water to the opposite side of the bent. The cables were again tightened with a hand spike used as a twister. The trestle thus built was very secure and carried traffic about five months and withstood a flow of ice and drift in the spring before it was dismantled.

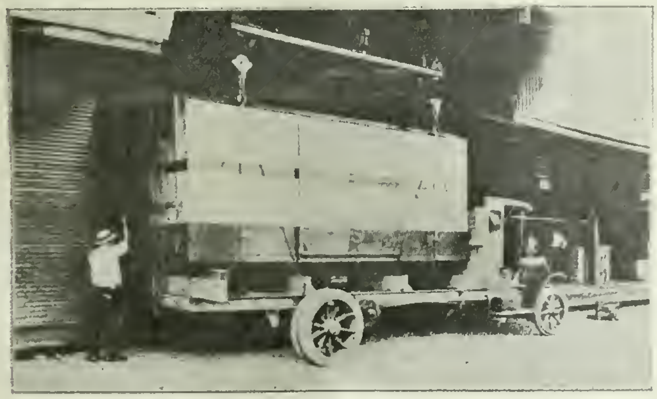
A. A. E. Becomes Member of American Construction Council.—The American Association of Engineers at the meeting of its Board of Directors on July 8 accepted the invitation of the American Construction Council to become a member of that body.

Use of Motor Trucks for Handling Freight

The development of the motor truck for hauling freight through city streets has caused much study of the extent to which it may be used economically as an adjunct to railroad service. As the motor truck can handle freight faster and at less cost on long haul than horse-drawn vehicles, it is peculiarly adapted to such service. The motor makes possible the consideration of district off-track freight stations as centers for store-door collection and delivery, freight containers, elimination of trap cars, and prompter service, even to those industries that have track connection. The recently issued report of the Engineers Committee on the St. Louis-East St. Louis Railroad Terminals, contains the following resume of recent developments in the use of motor trucks for handling freight in large cities.

Demountable Truck Bodies.—Demountable truck bodies are used at Cincinnati for handling connecting line l. c. l. freight between railroads and between main and sub-freight stations. The bodies are closed boxes 8 ft. wide, 17 ft. 6 in. long, 7 ft. high, with doors at the rear. They are handled by overhead cranes. The trucks have a capacity of 5 tons.

The bodies are placed on level with the freight house floors. The freight is handled directly between them and the cars. The boxes are loaded at the inbound houses, locked and sealed, and hauled to the outbound houses of the other railroads. After being emptied at the outbound house they are moved around to the inbound house for another load.



Demountable Motor Truck Bodies, Cincinnati, O.—Placing Body on Motor Truck.

The containers are used locally; they are not handled on railroad cars. While the bodies are being loaded and unloaded the motor trucks are handling other bodies.

When this system was installed in 1917 the freight was handled in part by horse-drawn drays; their capacity had been outgrown by the business and the railroads were rapidly returning to the expensive, slow and unsatisfactory trap-car service. The new system showed immediate benefits in quicker interchange, released trap cars for other service, released platform space, reduced platform labor, reduced the cost of transfer to the railroads, reduced loss and damage claims and released track room for station cars.

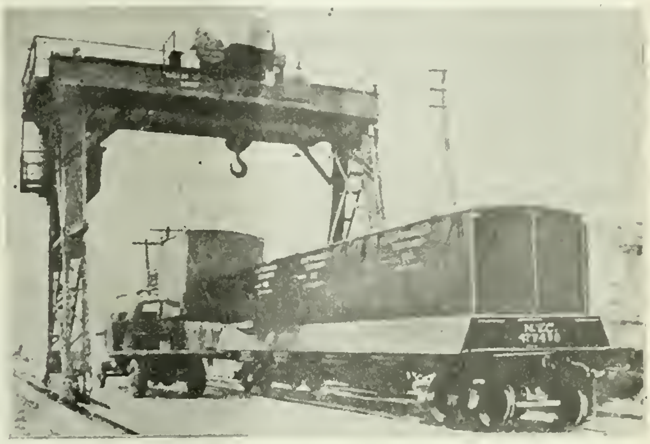
Container System.—The New York Central Ry. is conducting an experiment with far-reaching possibilities in the shipment of freight in steel containers. The system is not necessarily confined to l. c. l. freight, but may be used for certain freight that would otherwise be shipped in carloads. It is also adapted to the handling of express and mail.

The freight containers are of two sizes—7 ft. wide, weight 2,900 lbs., capacity 3,500 lbs., and 14 ft. wide, weight 4,800 lbs., capacity 7,000 lbs. Especially designed flat car with low sides carries six small or three large containers. When the containers are on the car the doors cannot be opened. Any flat car may be readily adapted to handling containers.

Containers may be loaded and locked on the shipping platform of the shipper, transferred to a motor truck, moved to a railroad siding, transferred to a car, transported to destination, transferred to a motor truck, moved to the consignee, transferred to the consignee's platform and there unlocked and unloaded.

This system reduces the number of handlings of freight, eliminates repeated checking, reduces the number and cost of clerks and truckers, practically eliminates losses due to theft and handling. Goods may be carefully packed by the shipper, frequently without crating, with the assurance that they will not be disturbed until delivered.

This system is admirably adapted to storedoor collection and delivery for the large shippers who make shipments that will fill containers. The extensive use of this system should cut down delays to trucks at freight houses and relieve freight houses of a great part of their present burdens. Cars and trucks can be loaded and unloaded in a fraction of the time now consumed in handling l. c. l. freight.



New York Central Container Car—Placing Container on Motor Truck.

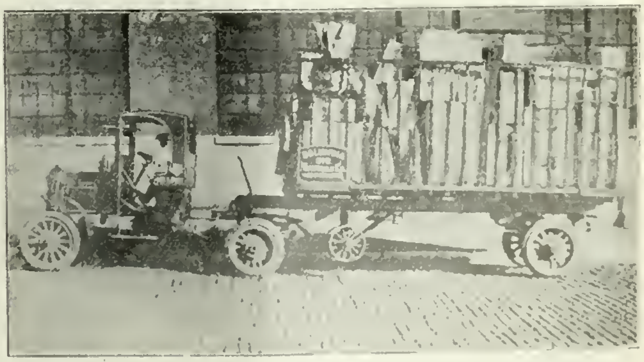
Experimental trips have been made between New York and Chicago and between Cleveland and Chicago. In a shipment of groceries from a Chicago firm to its Cleveland house 198 pieces were loaded in 33 minutes. The container was transferred to the car in 5 minutes. Nothing was crated. The goods were received in Cleveland in good condition.

This service cannot be substituted for the present method of handling l. c. l. freight, as there are so many small shippers, but it may be made an important adjunct.

This system should be given careful consideration by railroads and large shippers. It may be used to advantage by many shippers who have their own railroad track.

Columbia Terminals Tractor and Trailer System of Freight Handling at St. Louis and East St. Louis.—The l. c. l. freight that is handled between freight stations in the St. Louis-East St. Louis terminals and between the railroad freight stations and the off-track stations of the transfer companies is handled in wagon bodies with side stakes and a ridge pole. Each body carries a tarpaulin which is spread in wet weather. The greatest distance between stations is two miles.

Closed bodies were not adopted, as in Cincinnati, on account of the extra dead weight and the heat in summer. Movement under lock and key has not been considered necessary in St. Louis, as there has been practically no theft. The transfer companies' employes check the loading of the drays, receipt for the freight and get a receipt at the other end. This differs from the Cincinnati system, where the transfer companies' employes are merely drivers.



Tractor and Trailer Method of Columbia Terminal Co.—Ready for Delivery.

The St. Louis stake wagons are hauled by horses and as trailers to tractors. The wagons and trailers are parked at inbound platforms for loading and at outbound platforms for unloading while the horses and tractors are handling loads. The equipment is controlled by a dispatcher. The horses are gradually being replaced by tractors. At present the tractors haul across the river: the horses handle the shorter hauls on both sides of the river.

It is interesting to note that the motor tractors take only 18 minutes to make trips that take horses one hour.

The St. Louis system has all the advantages of the Cincinnati system, except the movement under lock and key, and is more flexible, as the wagons can handle at any point on the platforms of the shippers or freight houses without special preparation, other wagons may use the same space at other times, and no overhead cranes or mechanical equipment is required as for the Cincinnati bodies and the New York Central containers.

The trailers run on a rear axle and two heavy truck wheels. The front end, when detached from the trailer, is supported on a hinged frame with two small wheels under the body which permits the trailer to be moved around even when detached.

The front end of the trailer is picked up automatically and carried over the rear driving wheels of the tractor, which has four wheels. Thus a tractor and trailer have six wheels, two steering wheels, two driving wheels and two trailing wheels. The trailers have a capacity of 9 tons; the tractors are 3½ tons. The tractors average 20 miles per day with an average load of 6 tons.

This service has been developed to a high degree of efficiency, and is very popular with the railroads and the shippers.

Motor Trucks, Trailers and Containers Abroad.—Motor trucks, tractor trailer and container systems are in use by several European railways, largely for store-door delivery service, which is common in Europe.

The English railways have used railway containers for some years, particularly in handling mail, baggage and express to and from steamers to France and Ireland.

Natural Shrinkage and Swelling of Railway Embankment

Some interesting information on the subject of shrink and swell in fills was given in a report of the Committee on Roadway presented at the last annual convention of the American Railway Engineering Association.

The Southern Pacific Ry. made an investigation of eight railway embankments on a line, the building of which was discontinued in 1912 and work has not been resumed. Track was not laid on these embankments, therefore the shrinkage of the material was entirely natural and not augmented by trains passing over them.

The results obtained would probably be different had the fills been subjected to the compressing action of trains. An analysis of the results of the investigation shows that in every case other material than common earth was encountered in the excavation and placed in the fills. Each embankment had rock in some form.

The fill containing the greatest percentage of earth shows the greatest shrinkage and those with the greatest percentage of rock show the greatest swell. In the eight cases about 15 per cent. of the material was common earth, 65 per cent. was cemented material, 14 per cent. trap rock and the balance more or less of a solid formation.

Cross-sections were available for this work as of 1912 both as to material removed from excavation and material placed in embankment, and it was found that in six of the eight embankments the calculations showed an increase of some 6.61 per cent. to 21.34 per cent; the two remaining examples show a decrease or shrinkage of 5.67 per cent. and 9.83 per cent. The eight fills taken together show a swell of 7.768 per cent. above that measured in excavation.

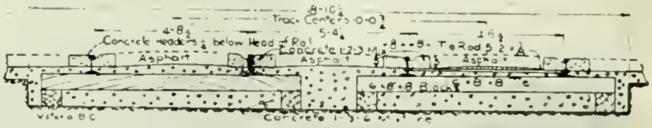
In 1920 the fills were again carefully cross-sectioned and the results show that in four of the eight cases there was a swell ranging from 0.997 per cent. to 17.24 per cent., and the four remaining cases a shrink of from 1.27 per cent. to 17.34 per cent. Taking an average of the eight fills a shrinkage of 0.362 per cent. is shown.

Special Concrete Headers for Street Railway Track

A special concrete header was used in the construction of 2,000 lin. ft. of double track in Victoria, B. C., for the British Columbia Electric Ry Co. We are indebted to Electric Traction for the details of this construction. The new track laid down is of the solid concrete type consisting of 7¼ in. high T-rail; length of rails 62 ft. with 6 in. by 8 in. by 8 ft. wooden ties spaced 3 ft. center to center. The rail joints are of the continuous type including the compromise joints at the connection with the special work layouts used in several street intersections.

Joints were bonded with two 4/0-⅞ in. diameter tubular bonds, 9 in. center to center of terminals concealed under joint plates. Cross bonds of 4/0 stranded cable, 5 ft. 6 in. in length of the tubular terminal type, were installed every 300 feet.

Tie rods of ⅞ in. diameter were affixed 24 in. from each joint and rods between these spaced equally, giving a total of eight tie rods per 62 ft. rail length. The track structure was blocked to grade and line by 6 in. by 8 in. by 8 in. blocks placed upon the prepared sub-grade. The concrete of 1:3:6 proportions was worked under and around the ties and to within 5 in. of the tops of the rails. Upon this course was immediately set the header forms and a concrete header of the proportion of 1:2:3 poured to within ¼ in. of the tops of the rails on the non-gauge side. The flangeway was formed by grooving the concrete in its plastic state by the use of a special wooden tool. Following up the main foundation course immediately with the headers assured one homogeneous mass of concrete, giving a total thickness of concrete at the rails of about 19 in. Concrete header strips on either side of the rails have a width of 8 in. and a depth of 5 in. The flangeway has a dimension of 1½ in. in depth with a width of 2½ in. from the gauge of rail. Immediately after the concrete headers were finished they were covered with canvas. The following day the canvas was removed and sand substituted. Sand was thoroughly hosed down daily for a period of two weeks. The accompanying illustration shows the type of construction of this trackage with the concrete headers.



Details of Track Construction in Victoria, Showing Concrete Header Along Rails and Wood Block Beneath Ends of Ties.

Wooden forms of 2 in. stock and with a width of 5 in., the depth of the header, were employed in setting the concrete headers. These forms were set upon the track tie rods which had been placed with a special work car. Spacing blocks 8 in. in length were used both for spacing the width of the header as well as spanning the header forms, thus permitting the continued use of form materials and interchanging the spacing blocks for spanners as occasion demanded.

Affiliation of Boston Technical Societies

During the past year informal meetings were held by representatives of the various technical societies in Boston, Mass., to consider an affiliation of these societies for more effective co-operation and for the advancement of the engineering profession. This consideration led to the formation on May 5, 1922 of "The Affiliated Technical Societies of Boston."

The affiliation was granted a charter on June 12, 1922, with the following nine societies as member organizations:

Boston Society of Civil Engineers, New England Water Works Association, Plant Engineers' Club, Boston Section, American Institute of Electrical Engineers, Boston Section, American Society of Mechanical Engineers, Northeastern Section, American Society of Civil Engineers, Boston Section, American Institute of Mining and Metallurgical Engineers, Massachusetts Chapter, American Society of Heating and Ventilating Engineers, Boston Chapter, American Association of Engineers.

Welding Manganese Special Trackwork

During the summer of 1921, some welds were made on manganese special trackwork at Syracuse, N. Y. The accompanying illustrations, reproduced from the Electric Railway Journal, show the condition of the trackwork after nearly 9 months' service. In an article in the above mentioned publication Mr. H. E. Bean, engineer of way and structures, New York State Railways, states that there are no appreciable depressions in the frog points and the results secured so far have been very satisfactory.

Referring to the illustrations, the welds on the castings shown in Figs. 1, 2 and 3 were made about Aug. 1, 1921. The welding in each case began near the point indicated by the arrow. The wear since the welds were made is about what would be expected from new castings, there being a slight tendency of the metal to flow, but no apparent brittleness, cracking or spalling off.

The weld on the casting shown in Fig 4 was made Feb. 20, 1922. This weld was made necessary by the breaking out of the entire frog point back to the point of the arrow. All of the frogs shown in Figs. 1, 2, 3 and 4 are located at the intersections of South Warren and East Genesee Sts. in Syracuse.

The weld on the hard center in Fig. 5 was made to give a through-running rail on the main line track with a jump frog condition on the cross track. This crossing is at South Salina and Water Sts. in Syracuse, and the filling in was made possible by the fact that the cross tracks are seldom used and then only for the storage of an occasional car which has become disabled in service. Fig. 6 shows a weld made on straight rail and indicates the result of ordinary track welding. In this case the weld was made at a coupled joint and, while the picture does not show it, the surface of the rail across this joint is in perfect condition.

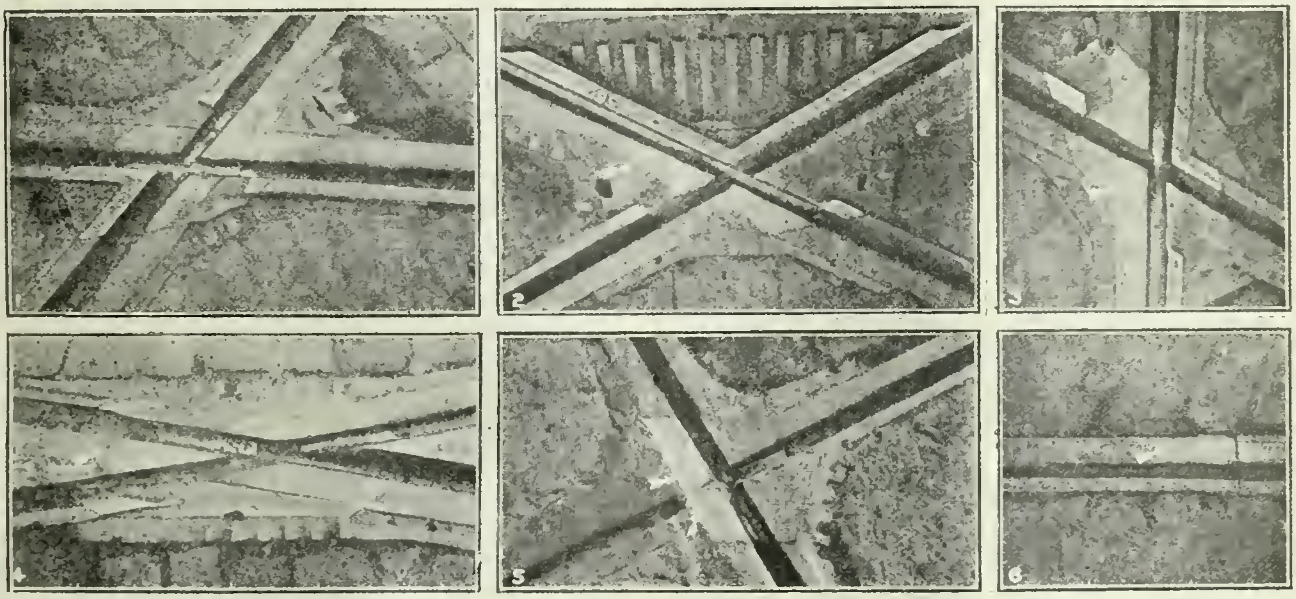
The car movements over the frogs shown in Figs. 1, 2, 3 and 4 are about 391 daily, or for 8½ months since Aug. 1 there have been approximately 99,800 car movements. The car operations over the frog of the casting shown in Fig. 5 have been at a rate of about 415 daily or a total of approximately 105,000 since the weld was made. It will be noticed from the illustration that the flanges of the wheels have made some depressions in the welded metal, but there is still sufficient running surface on the rail head aside from the flange bearing, which in some instances is built up and ground.

Method of Making the Weld.—In regard to the method of carrying out the work and of applying these welds to the special trackwork a very important factor is cleanliness of the parent metal. In this work we are now using a dilute solution of nitric acid. This acid has been cut with zinc to avoid the ill effects on the hands of the operators. The fumes from this acid, caused by welding, are disagreeable, and we are now experimenting with a neutralizing alkali in an effort to eliminate this objection. This, of course, is done after the acid has cleaned the metal to the desired extent. Wire brushing is also used to eliminate the scale or deposit of other foreign matter on the work.

The electrode used for depositing the metal is about a 15 per cent manganese coated electrode of ¼ in. diameter This is applied by means of a resistance outfit, special care being taken to insure that the proper amount of current is used. This is generally less than is used on straight work by approximately 50 amp.

Frequent quenching of the weld by means of water applied directly or with a wet mop appears to have a toughening effect on the deposited metal. The method of applying the layers of material is varied according to the shape of the weld and the judgment of the welder. On welds which are nearly square a criss-crossing of one layer upon another is generally used.

Care should be taken particularly to maintain a short arc, thereby allowing the molten metal to pass from the electrode to the work with a minimum of contact with the air. This reduces the oxidation to a minimum. A long arc has a much greater tendency to sputter and to move from one side of the electrode to the other, while the short arc has a much greater tendency to remain globular in form and to accomplish the required result. The retention of manganese in the deposited metal can be determined approximately by the comparative color of the two metals after grinding. Where the results are good it will be found almost impossible to observe the line of demarcation. Grinding is important, of course, in order to secure as smooth operation as possible. It is of course impossible to secure satisfactory results from welding frogs that are so badly battered that there is insufficient foundation upon which to start. When there is a notable depression due to battering, welding will prevent excessive pounding and will be less costly as well as giving better results if done immediately rather than if put off until loosening of the hard center or other failures occur.



Figs. 1, 2, 3 and 4.—Welded Special Trackwork at the Intersection of S. Warren and E. Genesee Sts., Syracuse. Fig. 5.—Through-Running Rail with Jump Frog on Unused Track at S. Salina and Water Sts., Syracuse. Fig. 6.—Ordinary Welding of Straight Rail.

Greatest Use of Railways Made in U. S.—At the recent international railroad congress at Rome reports showed that in use made of railway facilities this country heads the list with 46,000,000,000 passenger-miles and 300,000,000,000 ton-miles of freight in a year. Normally Germany occupies second place and Great Britain third. In this country freight cars have high carrying capacity, average of 2,800,000 cars being more than 40 tons. Tendency is to increase capacity, and many coal cars are 70 to 110 tons. Number of privately owned cars in this country is relatively small, only 6.6 per cent of the total of 2,800,000.

Breakage and Heat Treatment of Rock Drill Steels

A progress report to members of the Advisory Board to the Bureau of Mines and the Bureau of Standards on the breakage and heat treatment of rock drill steels and other steels and alloys subjected to similar impact stresses has been made by Dr. H. Foster Bain, Director of the Bureau of Mines, and Dr. S. W. Stratton, Director of the Bureau of Standards, covering the month of April.

On April 1, a survey was begun to determine the present status of the types and sizes of drills as related to the heat treatment and breakage of rock drill steels. Up to May 1, the following-named mines were visited by Messrs. F. B. Foley and H. S. Burnholz, metallurgists of the Bureau of Standards: The Osceola, Ahmeek and Isle Royal mines of the Calumet & Hecla Co.; the Champion mine of the Copper Range Co.; the Mesabi Iron Co. mine; the Ray Consolidated Copper Co. mine; the Copper Queen mine of the Phelps Dodge Corporation; and mines of the Calumet & Arizona Co., the Inspiration & Consolidated Copper Co., the Old Dominion Co., and the Miami Copper Co.

Carr Shape Bit Gave 40% Increase in Tonnage.—At the Calumet & Hecla mines the investigators were told that the development of the Carr shape of bit was the biggest forward step taken by that company in the development of their drill steel. A 40 per cent increase in tonnage per drill is claimed as a result of the change to this type of bit. The increase in the speed of drilling is attributed to the fact that the maintenance of gage enables them to use smaller gage steels, thus removing less rock per hole, because the speed of drilling increases inversely with the amount of material removed. Breakage is not considered a problem at the Calumet & Hecla mines. This company considers that a properly timed heating equipment, under an experienced eye, is as good, if not superior to, pyrometric control used in connection with the present types of drill heating furnaces where it seems out of the question to place a thermocouple in such a position that it can be depended on to tell the temperature of steels being constantly put into and withdrawn from the furnace. The drill sharpening shop of the Calumet & Hecla mines has a capacity of 3,000 drills per day, and they have run through as many as 4,000. In 1919 and 1920 the Calumet & Hecla Co., including all subsidiaries, used 750,000 lb. of drill steels, and in the same period removed 8,893,334 tons of rock.

Cross Type Bit at Champion Mine.—At the Champion mine, Painesdale, Mich., they use a double or cross type of Carr bit which they consider better than the chisel Carr used by Calumet & Hecla. They use mostly 90 per cent or so ⅞-in. hexagon steel. By the change to ⅞-in. hexagon from 1¼-in. round steel and the change from the old style cross bit to the modified double Carr bit, the company considers that it has been able to make a saving which has offset the increase in price of drill steel due to war conditions. They paid from 5 to 10 ct. per pound for steel in pre-war days and in 1919 the average price was 23 ct. per pound. The hardening furnace at this mine has a capacity of about 700 drills per day, but is at present being called on to treat 900 steels. For this reason they are now running their furnace at a temperature of about 1,525° F. The shanks are heated to an eye-estimated temperature of 1,425° F. and quenched in oil. The furnace which heats the steels for sharpening is similar to the hardening furnace, excepting, of course, that it is run hotter. It is similarly provided with a pyromter with which they regulate the furnace temperature to about 1,800°. Sharpening is done with a Leyner sharpener. It is the opinion of the investigators that in this district the improvements in the use of drill steel, and the reduction in the consumption of drill steel per ton of ore produced that has resulted, as compared to the consumption of drill steel in previous years, are largely the results of the development of types of bits and shanks suitable for the rock drilled and the machines being used, as well as the systematic methods developed of numbering drill steel and keeping track of it until it is either entirely used up, or until it is broken into such short lengths that it is of no further use and cannot be made into a bit of shorter length. Care and refinements of methods of sharpening have also been contributing factors.

Gill Bit at Mesabi Iron Co.'s Mine Gives Increased Footage.—The drilling at the Mesabi Iron Co. mine at Babbitt, Minn., is entirely a surface operation. The bits are 5 in. in diameter and are operated by a churn drill. Each drill weighs about 200 or 300 lb., and with the steam makes a train of tools weighing about 1,200 lb. The sharpening at Babbitt is done by heating the bits in a forge and roughly shaping them in a mechanical sharpener similar to that used in sharpening small mine drills, the edge is dressed up by sledging and the proper gage is given by the same means.

The greatest improvement so far attained at Babbitt has been in a change of the shape of the bit. Formerly the bit was a chisel-shaped one with two reaming edges. This bit held its gauge fairly well, but gave very slow drilling. Straight chisel bits, without reaming wings, drilled faster, but lost gage very rapidly. The bit now in use is called a Gill bit and has given them 8 ft. per drill shift where they formerly got but 3 ft. The gage of the Gill bits holds up better than anything they have used and gives good drilling speed. The company feels that, with improved methods in the smith shop, they may be able to get much better footage per sharpening than they now obtain. Records for the first two weeks in April show an average footage per sharpening of 1 ft., 3¾ in. The Bureau of Mines has undertaken to study the effect of controlling the hardening conditions.

Officials of the Ray Consolidated Copper Co. at Ray, Ariz., feel that they have no real drill steel problem. They have tried the Carr bit and state that they found no advantage in it in their rock, probably because of its soft nature. They are, therefore, using the straight cross type of bit with an angle of about 15° between the cutting edge and the side, clearance angle it might be called. The sharpening and hardening at this mine are done underground. Their furnace is oil fired and is run at an intense heat, probably 2,200° F., for both hardening and sharpening. Cruciform steel was once used at this time, but they have changed to quarter octagon, with the result that their breakage has been greatly reduced.

Copper Queen Mine Standardized on 1-in. Steel.—The Copper Queen mine of the Phelps-Dodge Corporation, Bisbee, Ariz., is standardizing on 1-in. hollow round steed for all their drilling operations. They have used and still have in use some 1-in. cruciform and ⅞-in. hexagon steel. They use a taper cross bit entirely. This is the type of bit commonly used at present, excepting in the Ray mines where they have a very easy drilling proposition. The bits at this mine are hardened by heating a small portion of the end and quenching cold in water. Their shanks are carefully made to avoid breaking near the collar of lugs. The operation of shanking takes three and sometimes four heats. The fact is recognized at the Copper Queen mine that attention to smith shop practice has improved their drill steel and resulted in better performance. They have tried a signal light type of pyrometer and found that it did not suit their purpose. Instead, they use a Shore Pyroscope to check their temperatures from time to time. The bulk of the drilling in the Copper Queen properties is in ground in which tests have given drilling speeds varying from 4.5 to 12 in. per minute, with an average of 8.75 in. per minute of reciprocating time. The ground has been carefully tested and classified in this connection, and the average speed given can be considered an accurate index to the "drillability" of the rock. Feet drilled per sharpening are as follows: stoping 7.5, drifting 4.16, and sinking 2.5, with an average of approximately 5 ft.

Double Taper Bits at Arizona Mines.—At the Calumet & Arizona mine, Bisbee, Ariz., the double taper bit is used, and the results are satisfactory. Their reasons for changing from the old style straight taper cross bit are the same as those found elsewhere. They consider their ground is somewhat harder than that at the Copper Queen. They have no great drill steel trouble since adopting the double taper bit. Breakage is not a serious problem at the Calumet & Arizona mine. Generally speaking, the metallurgists conducting this survey have not found that breakage is a serious problem. The general opinion is that the steel provided by the manufacturers is satisfactory and that breakage results from the peculiarities of the service and is small and confined to the neighborhood of the shank for the most part. One finds the opinion expressed very often that the steel near the shank becomes crystallized from constant use and fails. This is the first mine visited where bits were being drawn. For some of their harder drilling, their smith was observed quenching the bits in water and permitting the heat in back of the bit (only about ½ in. was submerged in quenching) to draw the edge to a point where a light straw was just appearing, after which he quenched the entire bit and withdrew the steel when it was at a temperature decidedly uncomfortable to the touch, say 150°. The steels were then piled in a horizontal position. They have no temperature control save the smith's eye. The furnaces at this shop are oil fired furnaces and are run at higher temperature than they need for sharpening. This is general practice in order to heat their steels more quickly to the sharpening or hardening temperature as the case may be.

At the mine of the Inspiration Copper Co., Miami, Ariz., a double taper bit is used, and they are contemplating standardizing on 1-in. round hollow steel. They now use ⅞-in. hexagon, 1-in. cruciform and 1¼-in. hollow round. Bits are hardened at this mine by quenching from a medium dark cherry in water. The steels are sharpened at a fairly high temperature. At present they are having some trouble with their shanks because of unskilled workmanship. At the Inspiration properties the drillability of the ground is estimated to give an average drilling speed of 10 in. per minute. Stoping performances is estimated as about 8 ft. per sharpening and drifting performance as about 6 ft. Breakage is estimated to be 5.8 per cent of the steel sharpened.

Drill steel is not regarded as a vital problem at the mine of the Old Dominion Co., Globe, Ariz. At this mine they use a double taper bit and have been able thereby to cut their gage changes in half. Smithing work has been reduced a third by the introduction of the double taper bit, through less wing breakage. The blacksmith shop foreman says they have no breakage whatever. The bits are quenched cold in water and the shanks are quenched in oil. In the Old Dominion properties the estimated drilling speed is 7 in. per minute. In drifting the estimated performance per sharpening is 4 ft. From estimates given, stoping performance figures about 19 ft. per sharpening.

Experiments with Detachable Bit.—At the mine of the Miami Copper Co., Miami, Ariz., they are experimenting with a detachable bit. This bit is fastened to the bar by a left-hand thread into a collar which, in turn, is screwed on to the bar. This company also uses the Shore Pyroscope for checking their smith shop temperatures. The sharpening furnace runs at about 2,000° F. and gives them steel for sharpening at a temperature which permits them to finish at from 1,500° to 1,600° in a single heat. For hardening the bits a second heat is given in an oil furnace in which the temperature is maintained at from 1,800° to 2,000° F. The bits are brought to a temperature of from 1,450° to 1,500° and quenched in running water 1 in. deep. Shanks to be hardened are heated for about 1 in. from the end, at a temperature of 1,500°, solid steel shanks are quenched in oil, hollow steel shanks are dipped in water, drawn to a dark straw color and quenched in oil. For forming lugs on shanks, 8 in. of the shank is heated for treatment. The method of handling drill steel at all of the properties visited in the Arizona district is similar. A nipper, or tool boy, loads a car of sharpened steel at the smith shop, and takes it to the shaft. The steel is lowered and taken to one of several distributing points without being discharged from the car. From the underground distributing centers the steel is delivered to the working faces by the nipper. In some cases the machine men themselves take a sufficient number of steels to the face to keep them supplied for a shift, as they pass the distributing centers mentioned above. Dull steel is picked up and delivered to the shaft by the nippers, who are required to make at least two rounds of the working faces every shift. In general, the idea is not so much to keep track of steel as to make sure that every machine will have a sufficient amount of steel at hand so as to absolutely eliminate any possibility of drilling at a face being held up on account of lack of sharp bits.

Work to Be Started Soon on 6-Mile Moffat Tunnel in Colorado.—Work may be started this year on the long projected Moffat tunnel through Continental Divide between Grand and Gilpin counties, Colorado. This tunnel will be approximately 6 miles long, will be single track, and will be equipped for electrical operation of trains. The total cost will be about $6,720,000, of which $3,288,000 will be for the tunnel work. The tunnel will be constructed under the direction of a commission of which L. D. Blauveldt, Denver, Colo., is chief construction engineer.

Methods and Cost of Relaying Double Track at Rochester, N. Y.

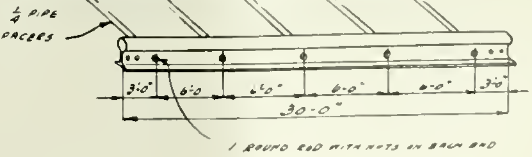
The New York State Rys. last year relaid 7,400 ft. of double track on University Ave., Rochester, N. Y. The work was carried out by building one track and then returning and completing the other track. On one side of the street there was placed 1,200 ft. of portable track connected with the main track by two turnouts at each end; in addition two portable crossovers were also placed at each end. The following information regarding the work is taken from Electric Traction.

The portable track was constructed with 70 lb. T-rail of 30 ft. lengths. Joints were placed opposite each other and rails were bolted together with 1 in. round rods, using 1¼ in. pipe for spacers. This track was laid directly on the pavement without ties, and was shimmed up with wooden shims where necessary and blocked with 2 in. by 6 in. planking between the curb and nearest rail. It was made up in the yard in 30 ft. sections for the purpose of transporting the work trains from the yard to the job and back again, saving the labor of dismantling track when necessary to change its location. All movements of portable track and crossovers were made at night.

TRACK COSTS.

			100 ft. of track.
Joints			
Joint plates	$ 2.27		
Abbott plates	.82		
6 bolts at 23.7c	1.42	(O. K. bolts)	
3⅓ joints	$ 4.51	per joint	$ 15.00
Rails and Rail Fastenings			
12½ tie rods	$ 0.60	$ 7.50	
⅔ keg of spikes	7.10	4.75	
2.76 tons 93-507 rail	73.10	202.00	
Hauling	....	3.70	
			$217.95
Ties			
7 oak ties at	$ 1.62	$ 11.34	
40 pine ties	1.44	57.60	
3 creo. ties	2.50	7.50	
Tie inspection, 50 at	0.026	1.30	
Hauling	....	4.10	
			$ 81.84
Ballast			
26 tons crushed stone	$ 1.84	$ 48.00	
Hauling	....	25.70	
			$ 73.70
Paving			
Cement, 62.5 bags at	70c	$ 43.80	
Rail block stone, 710 at	12.3c	87.30	
Paving block, 2,940 at	7.1c	209.00	
Gravel and sand, 25 yds. at	25c	6.25	
Labor	....	113.00	
			$459.35
Grading and misc. operating expenses			$137.00
Track and roadway labor			147.00
Bonding			
Material		$ 1.24	
Labor		1.88	
			$ 3.12
Engineering and superintendence			5.60
Temporary track, per 100 ft.			28.50
100 ft. of track			$1,169.06

After the construction work was completed in the 1,200 ft. strip, the portable crossover and turnout were moved ahead by sliding them along on the rails by aid of the work train.



Details of 30 ft. Unit of Portable Track.

Two motor flats were then connected to one end of the portable side track and it was moved ahead on the pavement to its next location. The other portable turnout and crossover was moved by the same method to their proper locations.

By the use of portable side track all old track could be removed with a Thew shovel, first removing the pavement and rails and loading on work trains direct. With the additional crossovers traffic is diverted to single track operation in non rush hours and permitted double track operation in rush hour service. This method allowed the transportation department to keep their cars on schedule at all times during the day without seriously interfering with the progress of the construction work.

After the old track and subgrade had been removed to the required depth the bed was rolled with a 10-ton tandem roller. The soft spots in the bed were removed and refilled with crushed stone. After this step, the crushed stone ballast to a depth of 6 in. was placed and rolled. On this ballast 6 in. by 8 in. by 8 ft. yellow pine untreated ties were laid, spaced 2 ft. centers. At the joints 10-in. ties are used. Seven-inch plain girder rail 60 ft. long was employed with staggered joints; also including 9/16 in. by 5½ in. cut spikes and ¾ in. by 1½ in. by 5 ft. 2¼ in. tie rods with ¾ in. terminals. The tie rods were spaced 8 ft. center to center. Tie rod holes were drilled with an electric track drill, and all tamping was done with mechanical tie tampers.

Six-hole fish plates were used, drilling 2½ in.-4-in-4 in. One inch holes were exact in diameter and located to take one-inch drive-fit bolts of high elastic limit. Under each joint was laid a base plate. An Erico type E C balanced brazed bond between 11¼ in. to 13 in. long was placed under the plate and installed by the Electric Railway Improvement Co. standard bonding car.

Each joint is thoroughly inspected for poor fitting plates, loose bolts and other defects before the pavement is laid, and all joints are ground, if necessary. The joints are inspected for a period of three years thereafter for looseness or for failures and steps are taken immediately to remedy the defect. This type of joint was used on a construction job in 1919 and the last two years' inspection has failed to find a loose or defective joint.

The concrete foundation for the pavement extends from 1 in. below the bottom of the ties to 1 in. above the top of the ties, and on this a 1 in. sand cushion was placed and spread. A 1:3:6 mixture of concrete was prepared with a machine mixer. Five-inch Medina stone block pavement was laid, and a cement grout 1:1½ mix brushed into the joints until they were thoroughly filled and present a smooth and even surface.

New Method for Revising Copper Map Plates

During the past few months the U. S. Bureau of Standards has aided in experiments made at the Coast and Geodetic Survey and the Hydrographic Office dealing with a new method for revising copper map plates. These engraved plates are quite costly and when a few changes are to be made upon them the expense is considerable. The method most commonly used heretofore has been to make an electrolytic alto of the plate and then to scrape from the alto those parts to be altered and to make by deposition a basso from the altered alto. The corrections were then engraved in the basso thus produced.

The method proposed by a member of the Bureau of Standards and which has been found to yield satisfactory results depends upon the deposition of metal by a projection of the electrolyte. This process was discovered a few years ago by the above-mentioned member of the Bureau's staff and it appears to be very successful for this particular work.

In brief, the process consists of directing a stream of the electrolyte, in this case a copper oxide solution, against the metal surface in such a way that a current passes from the anode contained in the projecting apparatus to the metal plate which forms the cathode. The metal then deposits only upon those points at which the stream of liquid is directed and not over the rest of the plate even though the stream of solution may subsequently flow over it.

In applying this process to the correction of the copper plate, it was found desirable to first remove the engraved parts to be altered as it was difficult to cause the metal to deposit in the bottom of sharp lines. This removal has been accomplished by using the same apparatus with a reversed current whereby the copper from the particular spot is dissolved to any desired depth, after which the current is made to flow in the usual direction, whereupon copper is deposited over the surface in a dense adherent form which can be readily polished to a smooth surface and engraved.

The results so far obtained by this method are very promising, and the Coast and Geodetic Survey is now engaged in securing the necessary equipment, which is comparatively inexpensive, so that the process can be used in its regular work.

The Motor Bus and Motor Truck as Auxiliaries of the Electric Railway

Advantages of Coordination of Motor Trucks and Busses with Electrical Operation, Outlined in Paper Presented June 27, Before Central Electric Railway Association

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The question of the economy of motor trucks and motor busses when used by electric railway companies has too many factors for anyone to offer much more than a statement of some of the operations already under way. For instance, six months ago, an officer of one of the Ohio electric railway companies made the statement that they were not interested in motor busses. At the present time this same company has determined that it will be economical for them to purchase, and their order has been placed for five special motor busses. These are to be operated on a highway paralleling their present lines.

Their decision was made from two angles entirely uninfluenced by the question of direct profit. In the first place, if they had not initiated bus operation covering the territory someone else would have started this service. Their franchise was in jeopardy because the public in the territory were not adequately served by the present electric service. Another factor was lack of capital to make the electric extensions, and their belief that the cost of additional track laying and equipment would be too great to prove a profitable investment at the established rate of fare.

Traction Company's Bus Line Prevents Competition with Its Trolley Service.—Another company, the Northern Ohio Traction Co. of Akron, found by careful study and survey that there was an opportunity to keep competition from its electric lines and at the same time operate busses at a profit by initiating two bus lines, generally paralleling their trolley service at a distance of several blocks off track. On one of these lines there was already partial jitney competition, but this competition will soon be entirely eliminated by the action of the trolley company in purchasing high class motor bus equipment and by its granting transfers from bus lines to the trolley cars.

An important factor in both these cases is also the opportunity offered by motor bus use to test the volume of traffic which may be secured in advance of making an expensive installation. Furthermore, should it be necessary later to either abandon the lines or prove more profitable to install electric trolley operation, the motor busses will have a large salvage value or may be at once transferred to other service.

These two cases are cited, particularly to illustrate that the question of economics in electric railway operation is not necessarily a question of making a specific profit on a definite installation of motor equipment.

Bus Lines in Territory Not Served by Railways.—On the other hand, there are hundreds of motor bus lines in operation in the United States in territory which was not being served by either the electric or steam companies. These hundreds of bus lines are delivering a profit to their operators. In some cases, as in California and a few of the Middle West cities, the patronage has already proven so profitable that passenger and transfer stations have been supplied by the bus operators.

It is reasonable to assume that this business belonged to the transportation companies, either the steam or electric operators. As it is in outside hands, it is evident this transportation business was lost to the regular transportation companies largely through lack of interest in their making surveys for motor bus operation.

Several of the larger electric and steam railway companies have, however, checked over their prospective fields and are now actively in the business of catering to the public's desire to "ride on rubber."

Street Railways that Have Conducted Busses with Electric Service.—At Milwaukee, the Milwaukee Electric Street Railway Co. made surveys which have justified their purchasing and operating 20 or more busses in co-ordination with their electric service. This action on their part has enabled them to conserve completely their investment in electric operation and to capitalize the "Rubber Urge" in making their extensions and in supplementing and supporting their normal service. In this way they have met conditions and fully satisfied the public demand for additional service.

Among the many street railway companies in the United States who have initiated bus service in co-ordination with their electric property operations are the United Electric Railways Co. of Providence, R. I.; the Pennsylvania & Ohio Electric Ry. Co. of Youngstown, O.; the Rockford & Interurban Street Ry. Co., Rockford, Ill.; the Connecticut Co. at various places in Connecticut, the Public Service Corporation of Newark, N. J.; the Street Railway Co. of Baltimore, Washington, D. C., and Tulsa, Okla.

Several of the New England companies have already initiated bus service and in California the electric lines are both operating busses as individual companies and in cooperation and in co-ordination with independent bus companies in order to issue through tickets for long trips. At Niagara Falls, the Gorge R. R. Co. supplements its service by a bus operation; the Escanaba (Mich.) Power & Traction Co., and the Northern Texas Traction Co. of Ft. Worth are also now on the list of users of both electric and gas motor bus transportation. At San Francisco and Seattle the municipal lines are co-ordinating both types of service in carrying passengers. As an evidence of the very rapid increase in the use of motor busses throughout the United States and in support of the statement that the public are enthused over the flexibility, convenience, economy and utility of the motor bus, it is most interesting to cite the fact that one manufacturer of busses has received orders for over 350 of a new model which was first announced to the electric railway and motor bus operators on Jan. 1, 1922.

What One Independent Bus Operator Has Done.—As transportation men, the electric railway operators will undoubtedly be much interested and possibly quite surprised to know that an independent bus operator, Frank Martz of Plymouth, Pa., carried more passengers per bus in 23 busses which he operated in Wilkes-Barre, Pa., in 1921 than were carried by the same number (23) of the busses operating on the Fifth Avenue Line in New York City. The figures are: For Wilkes-Barre, 183,891 passengers per bus; for New York City, 174,192 passengers per bus. In fact, the total passengers carried by Mr. Martz in the busses which he operates in Wilkes-Barre, Pa., territory was well in excess of four million passengers carried during 1921. Mr. Martz began hauling passengers in and about Plymouth, Pa., in 1910, and he reports that several of his busses have passed the 300,000 mile travel mark, that 8 have run more than 200,000 miles and that 20 have run more than 100,000 miles each.

Throughout the United States there are dozens of these independent bus operating companies, which have had a period of existence amply justifying the statement that motor bus operation is an economic transportation.

Motor Busses of Special Type.—Mention should also be made of the rapidly increasing use of motor busses of special type to transport vacationists, tourists and business men into scenic and resort territory previously inaccessible on account of the expense of establishing either electric or steam transportation on account of physical contours of the country and the seasonal feature of the traffic.

Motor busses may be driven over inexpensive highways and into hilly territory serving seasonal traffic and transferred to other territory at will. This frequently makes an operation very profitable through using these busses in service in the North in summer and in the South in winter.

Motor Vehicle Not Competitive with Steam or Electric Traction.—While at the present moment, in some isolated instances the advent of the motor truck and the motor bus may seem to initiate a new competitive unit and ultimately there may be numbers of lines of steam, electric and motor busses serving in the same community, the motorized vehicle will always be used for a type of economic transportation which, in general, is not competitive with either steam or electric operation.

It is an important fact that the motor on the highway offers the opportunity to supply the public with both local and express service operating over the same route, while this is impossible on single line rail.

It is very probable that a great many electric railway companies could profitably operate bus lines paralleling their rails, especially in congested centers, operating the bus lines for express service and using the electric service almost entirely for local stops. In many cities it would be possible to secure 10-ct. fare rates for such improvement in service and thus turn into a very proufitable operation a franchise which carried so much long haul traffic as to be otherwise unprofitable at the usual 5-ct. fare rate.

In other cases such a service might solve a rush hour congestion problem profitably where the addition of extra cars would only tend to slow up movement and increase congestion.

Another field for the use of busses in conjunction with electric line operation is in territory where development has spread the area served until a large percentage of possible short haul passenger business is lost on account of the distance the passenger must initially walk to reach the trolley.

The use of busses covering such a section over what might be called a curved or bow route paralleling the trolley service at some distance but not operating on exact trolley schedule would often prove distinctly profitable and preserve the existing company from possible competition.

The picking up and delivery at curb, whether in urban or in congested city territory is a psychological element to consider in the opportunity to increase short haul traffic.

The Desire to "Ride on Rubber" Important Factor.—An interesting phase of the great increase in the use of the motor bus is that the public have, through their ownership of motor cars, been educated to "Ride on Rubber." Probably this as much as anything else is the real reason why men, women and children will jam into and overcrowd the "jitney" and seem to prefer it in many cases as a means of transportation, even in places where the "jitney" service is paralleled by the electric railway.

It is largely the public who do not own cars that prefer the "jitney." It seems to be a vehicle of which the rider is more intimately a partner than in the trolley. The psychology of the entire situation is a vital factor. This is the "urge" back of the increasing use of busses.

Taxation of Motor Vehicles.—In the motorization of our highways the motor truck has been ranking next to the passenger car in importance up to the present time, but it is very probable the use of the motor bus will soon exceed even the use of the truck in the revolutionizing of our highway transport.

In this, it is very pertinent to comment on the subject of agitation in some sections to have the motor vehicle more heavily taxed.

Fundamentally, this is moving in the wrong direction except in so far as all vehicles using the highways may be taxed in proportion to their proper share of maintenance.

The motorization of our highways is itself the economic force which has compelled the betterment of our highways and to increase taxation of this special class group would seem to tend to drive backward instead of forward.

While the motor vehicle automatically demands good roads and the use of motor vehicles increases in proportion to the improvement in the mileagé of good roads, the all important point is that the mass citizenship are bettered by the improvement of roads.

Even the interests of the steam and electric roads may ultimately be served either by low taxation of motor vehicles than by high taxation. The steel rail carriers, both steam and electric, are the transportation industry. Sooner or later they will own and operate their own motor truck and motor bus lines, probably using trucks very extensively in store door delivery which is beginning to be demanded by merchants and wholesalers; and motor busses for the economic handling of their short haul and local passenger business and to supplement and probably in many congested districts to support or supplant already established lines.

In fact, as there are now dozens of electric railway and steam railway companies who own and operate both motor trucks and busses, they are just as much interested and will be more interested in the future in keeping down the taxation on motor vehicles as will the makers of motor equipment.

For this reason, it seems fitting that all transportation interests—the electric railway and steam interests, as well as the motor interests, can well refrain from agitating for taxation which may ultimately tend to become a boomerang tax, and thus prove burdensome to their own operations. Especially is highway tax agitation futile when it merely tends to widen the transportation cost breach existing between consumer and producer and as well to reduce the volume of goods which may be transported by motor for short haul and thus increases the unprofitable short haul tonnage to be handled by the railways.

The improper use of highways by overloading motor vehicles should be denounced and effective legislation enacted to curb this practice; but the statement made by Daniel Webster at Rochester, N. Y., Agricultural Fair on Sept. 24, 1843, is just as true today as then: "That one great duty of the Government is to see that the products of our rich soil and industrious labor may be easily, speedily and economically transplanted to the place of consumption and sale." Certainly the motorizing of our highways is a big step in furthering that end and Government might properly subsidize the increased use of the motor vehicle rather than penalize its use.

Motor Trucks in Service Department of Traction Companies.—The use of the motor truck by the electric railway service departments has naturally been proven economical as a factor in trolley operation much quicker than the use of the motor bus by the passenger departments.

In this service for public utility corporations, there are as many different kinds of uses for the motor truck as there are different types of work to be done. They are so varied it would be impossible to name them all.

A few statements of their service to the electric railway industry will suffice to suggest the possibilities: First, in importance, is undoubtedly speed in repair work. The public will forgive most anything except delays. When a break in a regular service occurs almost anywhere in the country the first call is for a motor truck repair outfit Day and night they are kept on guard.

Emergency Tower trucks speed at 25 to 50 miles per hour to repair line breaks. At one of the Georgia Railway & Power Co.'s sub-stations, for instance, a motor truck was used to move a 20-ton converter into position in the substation.

Where cable is to be strung on lines or go into conduit, the truck equipped with power winch is indispensable both for use in loading and unloading the reel at the warehouses and for paying out the cable or drawing it through conduit in the field.

Poles are carried into the field. Frequently the power of the truck or the winch is used in setting them up, greatly conserving the number of men required for this work as compared with the old method. Cross arms, insulators, transformers, tools and men all accompany the construction—often enabling one crew and one truck to perform work formerly requiring a number of teams and two or more crews.

Where excavation is required they are always on the job with tools, materials and men—dependable in all weather, durable through merciless punishment and most economical as well.

Where series of wires are to be strung on pole lines, some companies have rigged the trucks with special racks, feeding from eight to ten wires at a time, carrying all cross arms and insulators required at the same time. Many times trucks have been used by power companies to move buildings on their property.

Electric railway companies in a number of cases have had cranes mounted on motor trucks to assist in construction and repair work and to give speedy aid in removing obstructions if a line is blocked.

Motor trucks are used for patrol work; to haul fuel; to transport men and material on every kind of work, and anyone familiar with the field needs of electric trolley can specify dozens of other uses.

How a Cincinnati Company Uses Motor Trucks for Supplementary Freight Service.—In addition to the tremendous value which the motor truck represents in the service departments of the electric railway field, there is a use of trucks for supplementary freight service which may soon grow into large proportions.

A service for the extension of electric railway freight lines into off line territory as has been inaugurated by the Cincinnati, Aurora & Lawrenceburg Electric Railway Co. Finding themselves blocked for freight delivery and receipt at a point located 5 or 6 miles from the business center of Cincinnati, they have adopted the use of the demountable body or uniform container in use by the steam railroads of Cincinnati. They have established a service which enables them to meet steam railway competition and to give store door delivery. Arrangements were made with the Cincinnati Motor Terminals Co. to supply them with their specially designed container truck bodies and to supplement service from their outside terminal to the heart of the business center, by using these truck bodies on flat cars instead of using box cars for freight.

By this system, the truck bodies are immediately removed from the flat cars of the electric railway company just as soon as they arrive at their terminal. The Motor Terminals Co. immediately take them on their trucks, of which a large fleet is maintained in Cincinnati for steam railroad service. This enables the electric railway to make delivery to their off track downtown terminal within a few minutes after the arrival of the flat cars at the outside electric terminal. Or, when the consignment is in quantity it may be delivered direct to store door or warehouse of consignee in record time and without rehandling.

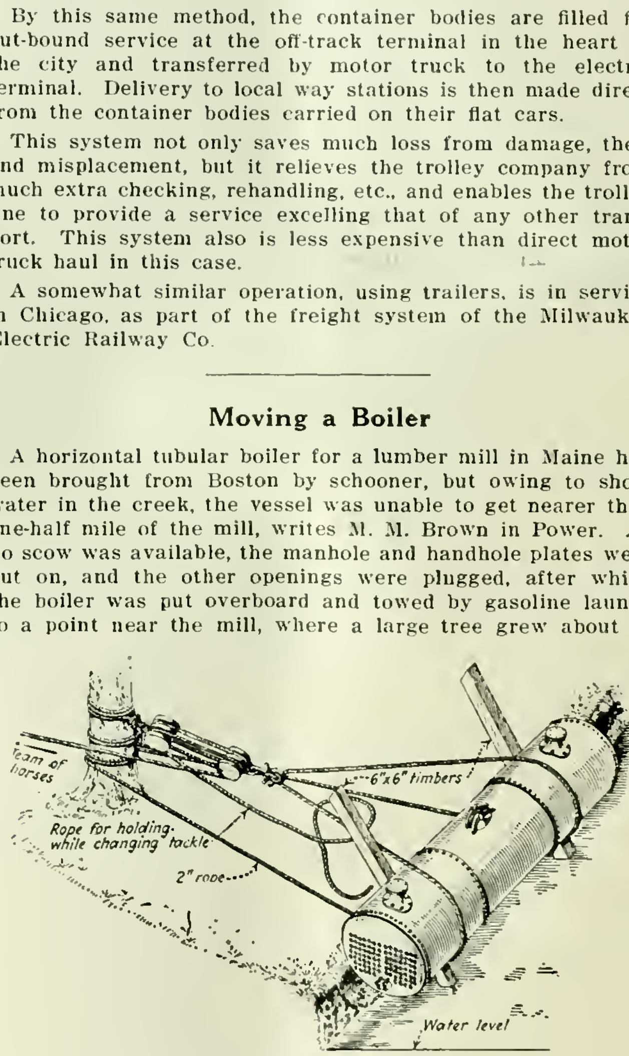
By this same method, the container bodies are filled for out-bound service at the off-track terminal in the heart of the city and transferred by motor truck to the electric terminal. Delivery to local way stations is then made direct from the container bodies carried on their flat cars.

This system not only saves much loss from damage, theft and misplacement, but it relieves the trolley company from much extra checking, rehandling, etc., and enables the trolley line to provide a service excelling that of any other transport. This system also is less expensive than direct motor truck haul in this case.

A somewhat similar operation, using trailers, is in service in Chicago, as part of the freight system of the Milwaukee Electric Railway Co.

Moving a Boiler

A horizontal tubular boiler for a lumber mill in Maine had been brought from Boston by schooner, but owing to shoal water in the creek, the vessel was unable to get nearer than one-half mile of the mill, writes M. M. Brown in Power. As no scow was available, the manhole and handhole plates were put on, and the other openings were plugged, after which the boiler was put overboard and towed by gasoline launch to a point near the mill, where a large tree grew about 15 ft. from the bank. At this point the water in the creek was 3 ft. below the ground level.



Method of Hoisting Boiler Onto the Bank.

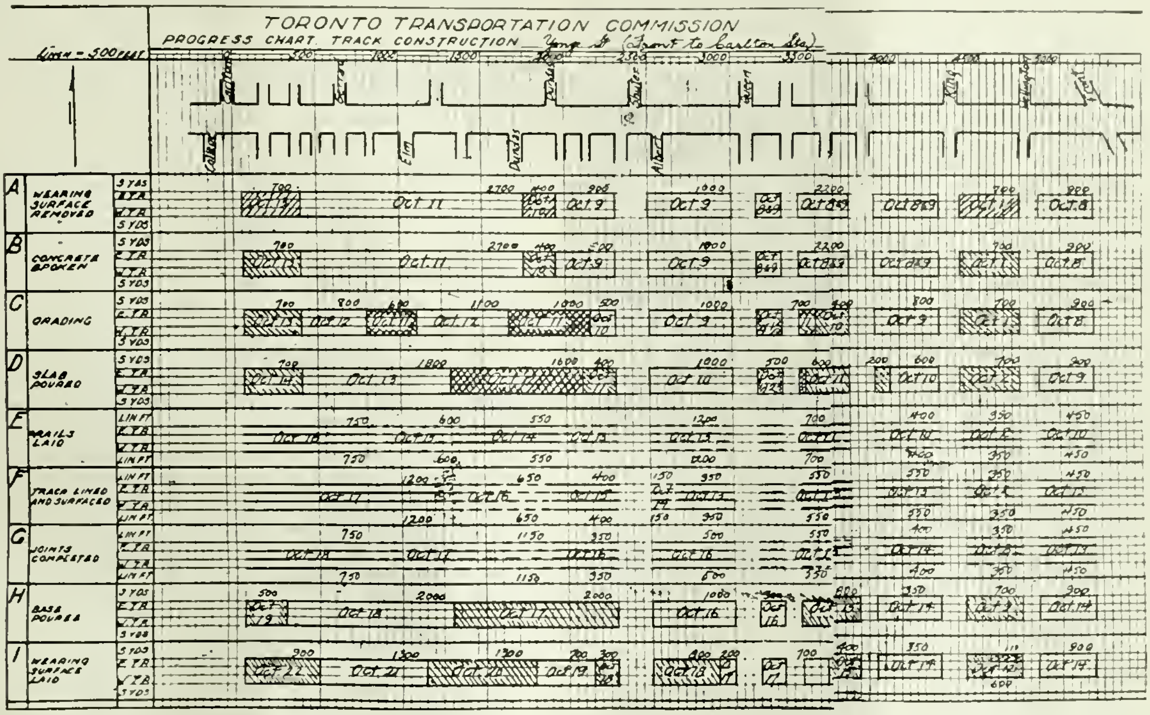
With tackle borrowed from the schooner, the boiler was hoisted to the bank, as shown in the cut. The bight of a 2-in. rope was made fast to the tree and a turn taken around the boiler halfway between the manhole in the center, and each end. The ends of the rope were then hitched to a four-fold tackle attached to the tree. An extra rope was provided, to hold the boiler while changing the tackle. Two 6x6-in. timbers were placed against the bank, and as the boiler came over the edge the timbers tipped inshore and served to hold the boiler off the ground, while the skids and rolls were put under it.

Special Chart for Recording Track Reconstruction Progress

In connection with the street railway track reconstruction operations at Toronto, Ont., of the Toronto Transportation Commission, progress charts were prepared for record purposes and to keep the commission advised of the exact state of the work at any particular time. The accompanying illustration from The Contract Record shows one of these charts.

The charts are plotted on paper especially squared to suit the nature of the facts recorded thereon. They are divided into nine sections, each representing one of the various operations in track reconstruction, viz.: wearing surface removed, concrete broken, grading, slab poured, rails laid, track lined and surfaced, joints completed, base poured, wearing surface laid. Horizontal lines in each section represent the two pairs of rails with the devil strip between. The vertical lines divide the chart into spaces each of which represents 50 lin. ft. of track. At the top, space is reserved for an outline map of the street undergoing reconstruction, which is drawn to the same scale.

Each element in the rehabilitation scheme is plotted as the work progresses, different colors being used to differentiate each day's work. There is thus presented a graphic representation of the situation along the route at the end of any particular day and comparisons are readily made between the outputs on any desired occasions. In reproducing the sample chart, it has been necessary to omit colors, and employ various hatchings instead. The dates are written on the squares affected, as are also the number of square yards or lineal feet finished.



Progress Chart Used by the Toronto Transportation Commission. (The original was on two sheets which were on slightly different scales; consequently in the reproduction above the two sections of the chart do not exactly match.)

To illustrate the working of the chart and to show the speed of the operations, take the sections of Yonge street between Wellington street and King street. It will be observed that on this section, about 375 ft. long, the wearing surface was removed, concrete broken, and grading completed on Oct. 1. The next day the slab was poured, the rails laid and the track lined and surfaced. On Oct. 8 the joints were completed, while the base was poured the following day. The track was entirely completed by the laying of the wearing surface on Oct. 12. A similar analysis may be made for any section of the street and in some cases the speed was even greater than on the section selected above. For example, the portion from Front to Wellington streets was finished between Oct. 8 and 14.

Similar charts were prepared for every piece of reconstruction undertaken, affording a condensed but accurate view of the whole situation—a necessity in view of the scale upon which the work was carried out.

53,000 Students at Engineering Colleges

The U. S. Bureau of Education at the suggestion and in co-operation with the Society for the Promotion of Engineering Education, has secured an accurate statement of the enrollment of students in the engineering colleges of the United States. The figures were obtained from a detailed statement of each institution, giving the attendance in freshman, sophomore, junior and senior courses, special students and graduates. The following table shows the enrollments in colleges of engineering according to specialization, for 1921-22:

Curriculum or Specification.	Freshman and sophomore classes.[1]	Junior classes.	Senior classes.	Special.	Total.[2]
Civil engineering	11,362	2,486	1,915	241	15,991
Mechanical engineering.	6,604	2,909	2,210	154	11,834
Electrical engineering ..	7,368	2,853	1,868	114	12,200
Chemical engineering...	2,727	1,304	1,106	101	5,028
Architecture	678	188	118	42	1,026
Arch. engineering	319	100	74	21	574
Administration engineering	346	215	164	0	725
Textile engineering	210	97	83	18	408
General engineering	300	130	85	224	764
Industrial engineering ..	193	110	75	11	389
Agricultural engineering	220	111	77	0	367
Commercial engineering	144	90	42	0	277
Ceramic engineering ...	84	24	21	37	166
Naval engineering[3]	50	27	34	1	112
Electro-chem engineering	43	24	28	0	95
Marine engineering	26	12	19	2	59
Aeronautic engineering.	21	10	15	2	62
Railway engineering[4] ...	20	12	16	1	19
Sanitary engineering ...	10	6	18	0	34
Chemistry	213	110	88	16	427
Physics and science	36	28	18	2	84
Industrial education	6	0	0	0	6
Industrial management.	5	1	3	0	9
Engineering economics..	12	2	8	0	22
B. S. degree[5]	9	0	5	0	14
Other specialties[6]	0	21	2	0	23
Mining and metallurgy..	1,172	576	428	140	2,669
	32,178	11,446	8,520	1,127	53,414

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[1] Freshman and sophomore classes are considered together because of duplication.
[2] Totals are not valid for comparative purposes.
[3] Includes naval architecture.
[4] Includes civil, electrical, and mechanical railway engineering.
[5] No specialized degrees offered.
[6] Automotive, electromechanical, geological.

The Needs of Railroad Construction[*]

By R. C. MARSHALL, JR.,

General Manager, Associated General Contractors of America

The United States has approximately 260,000 miles of railroad in operation, or approximately 2,600 miles per million inhabitants. In 1910 we had 2,700 miles per million inhabitants. The amount constructed in the decade just passed is less than 50 per cent of that constructed in any decade since 1860, and only 20 per cent of that constructed in the decade 1880 to 1890. The decrease in railroad construction has occurred since 1913; and to make up that deficiency, as well as to keep pace with a normal increase in population, will require the building of 6,000 miles of new track this year and every year for ten years.

Accumulated Demand for Construction.—I have indicated the existing deficit in railroad construction, which has piled up year by year since 1913. Railroad construction is not the only construction that has so piled up a deficit. This is also true of public utilities, public works, water developments, hydraulic developments, reclamation and irrigation and housing. This creates an accumulated demand for construction such as exists in no other country. This demand has been inarticulate. It has been unable to find expression for itself. The only phase of it that seems to have made an impression on the public is the demand for housing. The other phases of construction needs have not yet found their apostles who can beget the faith of the public in them. We are underbuilt in every particular except, perhaps, in industrial plants. Let us for a moment see what effect this would have on the business life of the country and its effect upon railroads. In a special bulletin prepared by the Chamber of Commerce of the United States, issued last June, it was stated that 25 per cent of the labor of manufacturers pertained to construction. This, of course, included the labor in connection with raw material, semi-raw products and the finished manufactured products. In considering construction in this its broad sense, some 20 per cent of the freight carried by the railroads in 1920 was for construction. Incidentally, I might say that, if this be the case, much of the public with whom the railroads will have to do business is that of the construction industry.

The general contractor is only one element of the construction industry, but he is an element through whose hands a large percentage, if not almost all, of the money passes that goes into that industry.

Economy in Continuity of Work.—Construction companies, like other industries, have found that economy depends upon continuity of operation, and that to hold their organizations together from year to year it is advisable to enter the several different branches of construction work. In the present inactive period of railway building, many companies who formerly did this work exclusively have taken up road-building and other types of work. They are thus able, in a measure, to build an efficient organization and to hold it intact by shifting it to first one and then the other type. In carrying out this policy, however, they are greatly hampered by a tangled conglomeration of contractual relations which interfere with uniform accounting and business practices. There are literally hundreds of contract forms used throughout construction, which vary greatly in their obligations, so that it is difficult for the field force, as well as the management, to keep in mind the detail requirements of every job.

One of the common criticisms heard concerning the construction industry is that it is not managed along the lines recognized and established in other industries, and that it is far behind in matters of estimating and cost-accounting. An extensive study into these matters has shown that this condition will not be overcome until the basic agreements under which they work are brought into some semblance of harmony. Under one contract the construction company may have certain obligations and under another contract in operation at the same time the obligations may be entirely different. The situation is very much the same as that confronted by an engineer in designing structures under the restrictions of different building codes. Yet in the case of these codes, as in the case of contracts, the ultimate objective is the same, namely: to secure safe and adequate construction economically built.

Better Understanding Needed.—Many revelations of conditions existing in the building and general construction industries, during the past two years, show a need of better understanding between that industry and the other industries for which it works. It should be clearly understood that many practices which have arisen in the building industry are traceable to the contracts under which that industry has been conducted. Upon this subject there is no longer any need of mincing words. A construction company cannot run its business along the regular principles followed in other industries as long as it is obliged to assume every risk under the sun. It is only in recent years that building contracts have been drawn so that they contain any semblance of mutuality. It was within the power of an architect to practically make or break a contractor, and, even though this authority might not be used, it constituted a hazard which no other industry tolerates. It is generaly known that construction cost for the same final result ran higher under one architect that another, and this fact the construction companies could not ignore.

Unfair Contracts.—Even today the contracts for highway work and paving work entail so many uncertainties that it is generally impossible for a construction company to estimate with any degree of accuracy. To read some of these contracts and to note that they are actually signed is enough to make one wonder whether the construction industry has gone crazy.

In the case of the railroads some years ago, construction contracts as drawn by the legal department were about in keeping with the general policies of sovereignty pursued by the road; and, had it not been for the fairness with which engineers administered these contracts, it is questionable whether railroad development could have taken place. A statement of one of the most successful railroad contractors in the country typifiies the situation. He remarked that he knew when he signed a contract he signed away his life, but that, knowing the engineers under whom he was to work, he believed he could complete the job and still own his equipment when he finished, and perhops some money. These are the conditions under which the construction companies have struggled to stabilize their industry.

Standardized Railroad Contracts.—The American Railway Engineering Association has done an excellent work in standardizing railroad contracts, but advices from various sections of the country indicate that in many cases the railroads have not grasped the value of such an undertaking. Some action should be taken to show them that a very urgent need in future railroad development is a standard of contractual relation which will permit dealing along the lines recognized and approved by modern industry.

In the evolution of business policies certain principles are being worked out, but it has been difficult to find an avenue of expression for them. This is true in the case of construction contracts. The fundamental principle that these contracts should express the rights of contractor and owner, so that the laws of proper economics might be carried out, has been working in the minds and consciences of those in the industry until at last it has found voice. This is recognized by the fact that in December a committee representing eight great national associations got together to consider this subject. The personnel of this committee and the people they represented should be sufficient for any of us to accept their conclusions. It seems to me perfectly certain that if this committee were to come to a unanimous conclusion, representing the composite individual opinions of those on the committee after they have extensively discussed the several questions involved, that each of us should realize that we would be acting in the common good should we accept that conclusion without reservation.

When any man has power, whether that power be for good or evil, he is reluctant to relinquish it. Fortunately, the spirit of the times is changing and this statement is becoming less and less true, particularly where the public is interested. As you all know, in times past the contractor on railroad work has depended more upon the personal equation of the engineer than upon the contract. As a matter of fact, the contract meant little either to the chief engineer or to the contractor. It is a further fact that, if the chief engineer died, all conditions of the contract were immediately changed and took on a new meaning in so far as the contractor was concerned. Certainly no rules of economics are observed when such a situation exists. The American Railway Engineering Association doubtless recognized this when they developed a standard contract document for the information and guidance of the several railroads in drawing their contracts. This document was a long step forward; and there are few engineering bodies who have taken such a step. The joint committee I have above referred to is basing its deliberation upon a consideration of the standard document of the American Institute of Architects and of your standard document.

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[*] Abstract of an address March 15 at annual banquet of the American Railway Engineering Association.

Two Hundred Contract Forms in Use.—I have in my office some 200 contract forms used all over this country. I think there can be no greater commentary on the lack of business methods of engineers and architects than the statement that I have just made, that I have some 200 contract forms used in construction work throughout this country. An examination of these forms indicates that one-half to two-thihrds of the clauses used in all these instruments are applicable to any type of construction work. This being the case, surely these clauses that are common to your many contracts can be put into one instrument so that the business conditions with respect to construction work wherever done can be alike, and thus construction work be made less of a gamble, less subject to individual vagaries and therefore more certain in its pricing.

The committee at its meeting determined that there are a number of subjects that are common to all forms of construction work. But it did not determine definitely that the subject matter of these subjects could be so expressed as to be acceptable in every case.

Universal Construction Contracts Urged.—It has been suggested that a universal construction agreement be adopted which will cover the obligations common to all work, leaving to several sets of so-called general conditions those provisions which are peculiar to each individual type. By such means it would be able to establish clearly the obligations of construction and to build up a strong foundation of precedents which would establish an ethical practice throughout. It is believed that through this procedure economy in construction and a raising of the standard of service can be most effectively accomplished.

In the case of railway contracts it appears to the contractor, at least, that these relations should be determined by the engineering department itself, leaving to legal talent the function of seeing that their principles are put into proper form. This policy has been carried out by the American Institute of Architects, and the lack of dispute and litigation under their standard document has thoroughly demonstrated its worth. The principle behind the move for standardization is to co-ordinate these existing standards and adopt universal clauses wherever they can be used. Though the legal talent might not profit by such standardization, the engineering department and individual engineers and architects undoubtedly would. This is one need of a railroad which concerns the engineering department directly, and which the engineers will have to sponsor if it is carried out.

There is still another need of the railways which greatly concerns their future expansion, and in which the engineers will doubtless find an interest. This is the development of more executives with both engineering skill and a knowledge of business and transportation economics.

Railroads' Perplexing Problems.—The difficulties attending future development of railways as private projects have greatly increased in complexity during the present generation. Railway executives are faced today with more puzzling difficulties than ever before. Labor troubles, legislation, Government regulation and transportation economics greatly complicate the study to be made in pushing out new lines. There will doubtless be a closer liaison between engineering and the study of present and future markets.

Motor-truck transportation has brought in new means of transportation, development of which should be intelligently co-ordinated with the railways. As the country is more intensively developed or productive areas are added to by reclamation, it is conceivable that motor transportation will necessitate great alterations in the layout of railway lines. As hard-surfaced roads with their motor-truck lines develop and feed into local centers, lines that were formerly branches of the railroad system may assume the importance of trunk lines. In any event, the preliminary studies that must be made before building new roadbeds and equipping lines must take into account this new element of transportation.

These new problems open an extensive field for combined engineering and economic studies. There is every reason to believe that the engineer can take up these studies of railroad building and solve their problems more readily than an executive with no engineering experience. In entering this field, he will be drawing farther away from what the economists might call the marginal engineer, who is in a great degree responsible for low professional compensation, and can perform a service fully as valuable as he is able to render in a crowded field of pure engineering. This new field offers an opportunity for development of the highest type of executive ability, and with it will doubtless go a high degree of prestige and compensation.

"Sand Hog" Hazards Reduced

The "sand hog," the toiler who works under abnormal degrees of air pressure in the construction of tunnels or mine shafts, is safer than he used to be, according to the United States Bureau of Mines. Health hazards which at one time were regarded as inherent in the occupation of shaft sinking and tunneling under the high air pressures necessary to keep back the water in wet ground and quicksand, have been greatly reduced. Observations made by Dr. Edward Levy, consulting physiologist of the Bureau, during the progress of tunnel work in and about New York City, indicate that the methods employed there have become so systematized and improved as almost to eliminate severe or fatal cases of compressed-air illness. The results of physiological studies made by the Bureau of Mines in the depths of its experimental coal mine at Bruceton, Pa., will be utilized in the construction of the vehicular tunnels to be built under the Hudson River between New York City and New Jersey and in the twin vehicular tunnels now under construction at Pittsburgh, Pa.

Caisson disease, compressed-air illness, or, more properly speaking, air embolism, is a condition caused by a too rapid decomposition after exposure to higher pressures for a period of time. The symptoms of compressed-air illness are vertigo, difficult breathing, localized pains, affections of the central nervous system, and unconsciousness or collapse. The formation of gas bubbles of nitrogen in the body fluids and tissues is the accepted theory at present of the cause of caisson disease.

In an employment so hazardous as that of a "sand hog" some attention should be paid to the class of men best fitted for it, the Bureau of Mines declares. Actual experience has led to the conclusion that in the selection of men the essentials are normal lungs, normal kidneys, and a good heart; in the older men the blood pressure must not be high. In the selection of workmen for compressed-air operations, the Bureau is not sure that advanced age is quite the important factor that many writers have insisted; neither is it considered that fleshy men are unduly susceptible to compressed-air illness.

Long before any great American projects requiring the use of compressed air were undertaken it was recognized that recompression was the correct treatment for compressed-air illness.

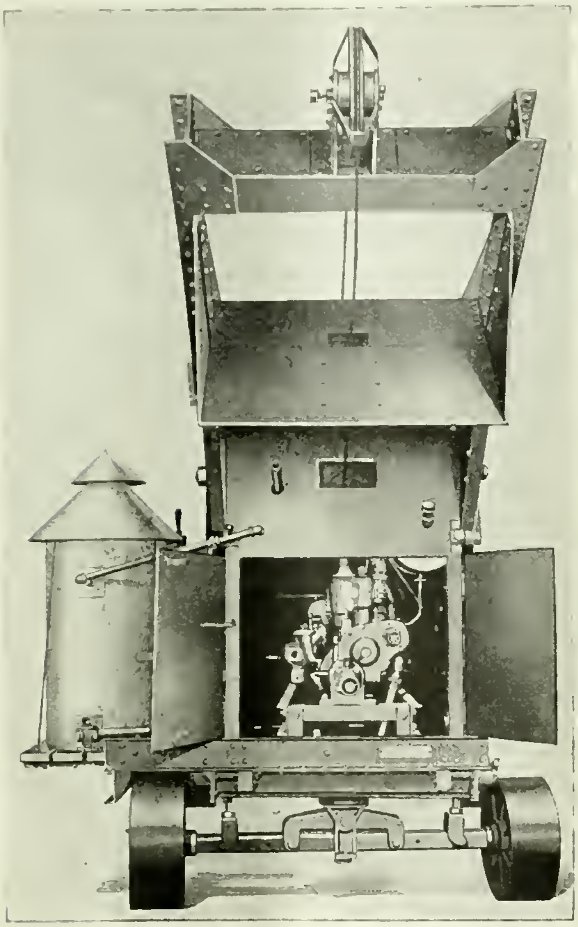
A worker suffering from compressed-air illness should be put in a medical lock and the pressure rapidly raised to that in which he had previously worked. It is a good policy to keep the patient at this pressure for a short time in order to be sure that the bubbles of nitrogen have been thoroughly compressed and again taken up by the circulation. The patient may then be decompressed again by the stage method, except that now the time should be double in every part of the decompression. Although symptoms are frequently relieved before the pressure in which the man had worked is reached, it is safer to attain the original pressure before decompressing.

Few states have legislative measures protecting the welfare of men working in compressed air. Only three states—New York, New Jersey and Pennsylvania—have any laws regulating the hours of labor and the hygienic conditions to be observed in such work.

Portland Cement Output in June.—The total production of portland cement in June, according to the U. S. Geological Survey was 11,245,000 bbl., and the total shipments were 13,470,000 bbl. The amount in stock at the end of the month was 10,668,000 bbl.

New and Larger Motor in Smith Excavator and Loader

The consistent service provided by the Wisconsin 4-cylinder gasoline engine used on Smith pavers has led to the adoption of this make of motor on Smith excavators and loaders, made by The T. L. Smith Co., of Milwaukee. The new motor, shown in the accompanying illustration, has 3-in. bore and 5-in. stroke and runs at 1,200 r.p.m. It is stated that the new motor increases the power of the machine by about 40 per cent. The excavators and loaders are used for general dragline excavating, for digging basements and loading directly into wagons or trucks on the surface; for grading, stripping, and miscellaneous earth handling and loading.



End View of Smith Excavation and Loader Showing New Motor.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

Cox Bros., Indianola, Iowa, have 60,000 yds. of state highway work at Lancaster, Mo., and 200,000 yds. at Bloomfield, Ia., also a good sized job at Waverly, Ia., to sublet in quantities to suit outfits.

J. McClavy has moved his outfit on to a new job at New Canton, Ill. Has enough work there to hold him until the beginning of winter.

J. J. McInerney expects to finish his work at Hartford, Ill., shortly. Is looking around for a job suitable for a 13 team outfit.

Cleary & Hailey, 407 Lyric Bldg., Cincinnati, Ohio, want to sublet 80,000 yds. of state highway excavating, concrete bridge and culvert work on 1¼ miles of highway in Hamilton County, Ohio.

C. H. Cummins and R. Hatfield of the C. R. Cummins Co., Cleveland, O., were with us a day. Hatfield is in charge of their big grading job at Denison, Tex. Says he will finish this work within a couple of months. The Cummins Company have a dragline idle at New Memphis, Ill., that they would like to place on some work immediately or will sell or lease it. Swetland Bldg., Cleveland, Ohio, will catch them.

Bricker & Walker, Orient, Ohio, want work for a 10 team and light shovel outfit. Prefer railroad work in Ohio, Indiana and Illinois.

Bates & Rogers Const. Co. of Chicago were low bidders on the Santa Fe work in Kansas.

I L. Simmons, La Plata, Mo., is figuring on taking 5 miles of the L. J. Smith bank widening on the M., K. & T. R. R. in Kansas.

S. H. Harris has subbed 5 miles of bank widening on the M., K. & T. R. R. between Parsons and Paola from the L. J. Smith Const. Co.

Willis Dunlevy is moving his outfit on the M., K. & T. R. R. between Parsons and Paola on 5 miles of betterment work that he subbed from the L. J. Smith Const. Co.

L. J. Smith Const. Co., Commerce Bldg., Kansas City, has some splendid slip and station work to sublet on the M., K. & T. R. R. between St. Louis and Boonville, Mo. The work consists of bank widening. No work in cuts and no fills over 5 ft. high. Will sublet this in quantities to suit outfits.

Morris & Dougherty were low bidders on the Burlington R. R. work at Beardstown, Ill. This work consists of repairing and raising tracks that were washed out some time ago by high water. About 150,000 yds. of dirt to be moved.

Ira I. Printy, Bonnie, Ill., will finish his road work there in a few days Is hunting for work in this part of the country.

A. L. Cook, Ottawa, Kan., was awarded contract for building a reservoir for the M., K. & T. R. R. at St. Jo, Tex. About 50,000 yds. of earth, 2,000 yds. of concrete, 2,000 yds. of riprap and about 7,000 ft. of pipe line in this job.

Cox Const. Co. and Yale & Reagan are putting on night crews on the Frisco R. R. near Meramec Highlands, Mo.

Brooks-Callaway Co., Bauxite, Ark., will have 6 large and 5 small shovel outfits, also a brand new tunnel outfit, idle shortly. Are anxious to place these on some new work.

The Walsh Construction Co., Muncie, Ind., have a small team job to sublet at Monee, Ill.

L. S. Cooper & Sons, Brighton, Ill., have a 16-team outfit idle and Frank Cooper has 15 teams idle at Hartfort, Ill. Can move these outfits on work immediately.

Riley & Bailey, International Life Bldg., St. Louis, Mo., have about 750,000 yards of wheeler work at Fulton, Mo., on state highway, to sublet.

Russell Condon, another good old-timer, has passed away. Russ died in Omaha on June 25. Had a slight infection on his nose, paid no attention to it until too late, when blood poison set in.

Frank McCaughey of the J. J. McCaughey Co. report all of their jobs as getting along nicely. So far they have not experienced any shortage of labor.

Tom Walsh of the Walsh Construction Co. stopped off a day here returning from their job on the Frisco R. R. near Paola. While here Tom met quite a few of his old college chums.

Contractors when in want of work or labor for their outfits write or wire Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., or 501 Delaware St., Kansas City, Mo.

Leo B. Robbins is finishing his road work near Carbondale, Ill. Wants another job to place his team outfit onto. Write him at Dowell, Ill.

Otto Piffel, 345 Calvert Ave., Webster Groves, Mo., has an 8-team outfit idle that he would like to place on work in this neighborhood

Personals

Col. Arthur S. Dwight and **Charles F. Rand,** president and treasurer, respectively, of the American Institute of Mining and Metallurgical Engineers, have been made Chevaliers of the Legion of Honor by the French Government for distinguished service during the war. Col. Dwight helped organize the First Reserve Engineer Regiment, which as the Eleventh Engineers was the first unit of the American Expeditionary Force to go into action. He was decorated with the Distinguished Service Order by the British and was cited in orders by Gen. Pershing. Mr. Rand discovered large soft iron ore deposits on the north coast of Cuba and built the Barraco Railroad there. In 1913 King Alfonso XIII of Spain decorated him with the Grand Cross of Knight Commander of the Order of Isabella Catolica.

Charles D. Campbell of Hamilton, Ont., has been appointed city engineer of Belleville, Ont. He was for five years municipal engineer for Galt, as well as Hespeler and Preston. He was resident engineer of the Galt, Hespeler & Preston R. R.

Prof. George W. Patterson, a member of the engineering faculty of the University of Michigan for the past 33 years, has been appointed assistant dean of the engineering college by the board of regents. Prof. Patterson came to the university in 1890 as an instructor. He was later made junior professor of physics and in 1905 professor of electrical engineering.

R. A. Fishburn of Tucson, Ariz., has been named consulting engineer of the Mexican Boundary Commission, with headquarters in El Paso, Tex. The matter of appointing an American boundary commissioner is still under consideration.

Donald E. Payne, Boise, Idaho, has been appointed instructor in civil engineering at the University of Idaho.

George Mercier, Jr., heretofore foreman of yards of the Boston & Albany R. R. at West Springfield, Mass., has been appointed assistant supervisor of track between Boston and Worcester, Mass.

F. W. Blitz has been appointed supervisor of track of the Philadelphia & Reading Ry. with headquarters at Olney, N. Y.

G. W. Hegel, chief engineer of the Chicago Junction Ry., has resigned to go to Los Angeles, where he will have charge of an important construction enterprise in connection with new stockyards connected with the Union Pacific. T. Broom, secretary of the Chicago Junction, has resigned to become treasurer of the syndicate which is to construct the new yards, of which J. A. Speer, A. J. Leonard and H. E. Poronto will constitute the managing board.

W. W. Waldrop has been appointed general superintendent of the Southern Division of the Pennsylvania R. R. at Wilmington, succeeding the late Gamble Latrobe. Mr. Waldrop has heretofore been general superintendent of the Michigan Division at Grand Rapids. Other appointments follow: J. B. Hutchinson, Jr., to be general superintendent of the Michigan Division. He had previously been general superintendent of the Toledo Division. T. A. Roberts, at present acting superintendent of the Fort Wayne Division, to be general superintendent at Detroit and superintendent of the Toledo Division. P. H. Pinkham, to be superintendent of the Fort Wayne Division. He had been superintendent of the Norfolk Division at Cape Charles, Va. F. D. Davis, at present division engineer of the New York Division, to be superintendent of the Norfolk Division.

Industrial Notes

The Jointless Fire Brick Co., Chicago, Ill., have placed an order with the Weller Manufacturing Co., Chicago, for equipment, which will double the capacity of its plant, without increasing their working force. Power shovels will remove the clay from the box cars into a pit where a reciprocating feeder will feed to an elevator thence to spiral conveyors to bins. The capacity will be 20 tons per hour.

Building and Structural Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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E. & C. Index Furnished Only on Request

The index for Vol. LVII—January-June, 1922—issues of Engineering and Contracting will be ready for distribution shortly. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Rational Versus Empirical Methods of Forecasting Commodity Price Levels

Prognostication of future prices based on the price trend during past years has no sound reason to support it Take the commodity price indexes every year for the last century, and consider the errors that would have occurred had attempts been made to forecast the price level, say, five years in advance of any given year by projecting the price curve forward.

About 18 months ago a man who calls himself a public utility rate expert testified before a public utility commission that prices would soon be back to the prewar level, for at the rate of decline that had occurred in the preceding eight months it would take only eight months more to get back to the price level of 1913; and that testimony seemed to carry great weight with the commission!

Absurd as it is to forecast a price trend based on a few preceding years, the absurdity is even worse when a few preceding months are made the basis for such a prediction.

For the past six months the wholesale commodity price level has been slowly rising. This in itself is no sound reason for predicting a continuation of that rise at the same rate. Are we then left with no means of forecasting price levels?

We can predict the future only by using past experience, but we are not confined to the experience of the immediate past. We should seek to ascertain what are the forces that affect price levels, and we should quantify each of the forces, or their resultants. If this is done, and if the resulting theory gives quantitative results that agree substantially with all past records, then we are possessed of a reliable means of forecasting future price levels, if we can forecast the quantity of each of the factors. Any other method of forecasting price levels is quite as apt to be wrong as right.

Fortunately, there are only four important factors that affect commodity price levels, namely, (1) quantity of currency in circulation, (2) its rate of "turnover" or velocity of circulation, (3) population, and (4) per capita efficiency of production. The last two factors are very accurately ascertainable, and since they usually change quite slowly and with considerable regularity, they can be predicted with much precision. This leaves only two factors that are at all difficult to forecast, namely, quantity of money and its velocity of circulation. The product of these two factors constitutes the total purchasing power of a nation. The product of the other two factors constitutes the total productivity of a nation. The first product divided by the second product gives the average commodity price, or price level.

Velocity of money circulation is a factor that oscillates about a mean, increasing in good times, decreasing in bad times, but seldom departing more than 15 per cent from the mean or normal. Bank clearings, divided by bank deposits, can be used to estimate the changes in this factor. Although errors may be made in forecasting this factor, there can be practically no error if the object is to prognosticate a future price level when business is normal, that is, neither booming nor depressed; for in that case we have but to assume the mean or normal velocity of money circulation.

So, for the purpose of forecasting the future commodity price level when business is normal, there is left only one factor (the quantity of money in circulation) that is at all difficult to estimate. But even here the per cent of probable error in any estimate for the next few years in America is not great.

Our paper currency is based on bank credits, which in turn are limited by the gold reserve. Our per capita gold is about 80 per cent above the 1913 average, and since the world is our debtor, we are not apt to lose much of our gold. Hence, with the removal of business our bank loan (credits) will expand, and with them the Federal Reserve notes (paper money), until the per capita currency is fully 80 per cent above that of 1913.* This means that commodity prices will probably rise to fully 80 per cent above the 1913 level. Our wholesale commodity prices are now 50 per cent above the 1913 level, and our retail prices about 60 per cent above that level. A 20 per cent rise in wholesale prices and a 12 per cent rise in retail prices will put them both at the 180 level, as compared with 100 in 1913.

During the past two years, in the face of almost unanimous predictions of a steady decline in prices, we have predicted a substantial rise to a level 60 to 80 per cent above that of 1913 Our predictions have been based on the four factors above named, and not on price trends. In short, we have used rational instead of empirical methods.

Increase in Cost of Living, with Special Reference to Rent

The increase in residential rents since 1914 ranges from 27 per cent in Portland, Me., to 96 per cent in Los Angeles, Cal., according to cost of living statistics for 320 cities published recently by the U. S. Bureau of Labor. The following percentages give the average increase in "housing" (or rental) expense in each of 19 cities from Dec., 1914, to March, 1922:

	Per cent.
Baltimore, Md.	65
Boston, Mass.	34
Buffalo, N. Y.	62
Chicago, Ill.	84
Cleveland, O.	77
Detroit, Mich.	88
Houston, Tex.	40
Jacksonville, Fla.	38
Los Angeles, Calif.	96
Mobile, Ala.	48
New York, N. Y.	55
Norfolk, Va.	92
Philadelphia, Pa.	49
Portland, Me.	27
Portland, Ore.	43
San Francisco, Calif.	28
Savannah, Ga.	59
Seattle, Wash.	67
Washington, D. C.	31

The percentage increase in rents in 13 cities, from Dec., 1917, to March, 1922, is as follows:

	Per cent
Atlanta, Ga.	72
Birmingham, Ala.	68
Cincinnati, O.	30
Denver, Colo	84
Indianapolis, Ind.	42
Kansas City, Mo.	65
Memphis, Tenn.	76
Minneapolis, Minn.	47
New Orleans, La.	58
Pittsburgh, Pa.	55
Richmond, Va.	34
St. Louis, Mo.	64
Scranton, Pa.	47

According to the U. S. Bureau of Labor average rents increased only one-tenth of one per cent between Dec., 1914, and Dec., 1917. Hence the increases for the 13 cities are comparable with the increases for the 19 cities.

The average increase in the cost of living in the 32 cities between the year 1913 and March, 1922, was 67 per cent, distributed as follows:

	Per cent
Food	38.7
Clothing	75.5
Housing	60.9
Fuel and light	75.8
Furniture	106.2
Miscellaneous	103.3
Weighted average	66.9

Although the average rent in the 32 cities increased 61 per cent, there are wide departures from the average. It will be noted that rents increased to a greater extent in the rapidly growing cities than in those of slower growth. This leads us to infer that rents in the smaller cities have increased considerably less than the 61 per cent average for these 32 cities. Hence it seems probable that taking all cities in America the average increase in rents is less than 50 per cent—possibly only 45 per cent—above the average for the year 1913.

Somewhat the same is doubtless true as to the increase in the average cost of living in America.

The National Industrial Conference Board gives the following percentage increases in the cost of living between July, 1914, and March, 1922:

	Per cent.
Food	39
Shelter	65
Clothing	54
Fuel and lighting	74
Sundries	74
Weighted average	55

The cost of living in April was exactly the same as in March, according to this Board.

It will be noted that average rents have increased almost in proportion to the increase in the cost of building construction. This was to have been expected in all cities whose growth has been such as to produce a house shortage.

We are of the opinion that building construction costs and city taxes will rise somewhat during the next two years, and that consequently average rents will rise.

Food prices will probably rise to a marked degree, and since food constitutes about 38 per cent of the average living expense, it is obvious that a moderate rise in food prices will have a marked effect on living costs.

The following table gives the weight assigned to the different factors, column (1) referring to the U. S. Bureau of Labor, and column (2) to the National Industrial Conference Board:

	(1).	(2).
Food	38.2	43.1
Clothing	16.6	13.2
Shelter	13.4	17.7
Fuel and light	5.3	5.6
Furniture	5.1	....
Miscellaneous	21.3	20.4
Total	100.0	100.0

Our Reason for Omitting a Table of Contents

For several years it has been our practice to publish Engineering and Contracting without a weekly table of contents. Every six months we publish an alphabetical index which is sent only to those readers that request it.

In a periodical that has as great diversity of articles in each issue there may be need of a table of contents in which the title of each article is given; but where the articles are specialized, as they are in Engineering and Contracting, the need of a table of contents is practically nil. The editors have occasion to refer to their magazine several times more often than does any subscriber; and as editors we have not felt the need of a table of contents.

We doubt whether a single one of our 10,000 subscribers has ever timed himself to ascertain how long it takes to run through the pages of an issue and read the title to every article. It takes just one minute. That fraction of this infinitesimal part of a week could be saved were there a table of contents! It takes three-quarters of a minute to read the average table of contents, so that a table of contents saves a quarter of a minute a week. But this insignificant saving of time is effected at an expense that is usually overlooked.

Tables of contents rarely contain the titles of minor articles or "fillers," which though brief, often contain valuable data. Tables of contents give neither titles of illustrations nor sideheads, and of course they show no illustrations. All of this can be scanned in 2 to 3 minutes of time.

It is our opinion that any reader who does not thus scan every page of every issue is making a grand mistake. Indeed, we may safely go farther and lay down this principle: Any engineer or contractor who fails to spend 15 minutes scanning every page of articles and advertisements of every issue, is likely to fall behind the current progress in this great field.

There is no index so good that it can be relied upon to the exclusion of the memory. Every man admits this when he asserts that personal experience is superior to printed information; for the main element of superiority lies in the fact that personal experience is better remembered. The contractor who has helped gather up the fragments of one of his workmen, who was thawing dynamite over a hot stove has no better experience than is given to him in a book on blasting, except in one respect: He will never forget that personal experience and he is apt to forget what the book has told him about thawing dynamite on hot solids.

The best part of every man's knowledge is the part that is in his mind—memorized. Even when he comes to refer to books and magazines for a desired sort of information, his memory of what he once read or scanned usually leads him to the desired source of information more quickly and more certainly than he would be led by an index.

Memory training is mainly affected by taking interest in a given subject and by repeatedly viewing the different details of it. Other things being equal the man with the best memory relating to a given subject is therefore the one who has given most time to reading about that subject.

50 Per Cent Increase in Number of Engineers in Ten Years

The following weekly summary of conditions in the engineering and construction field was written by the editor of Engineering and Contracting for the Chicago Journal of Commerce:

Census statistics are now available to show the growth in the engineering profession. In 1910 there were 136,000 engineers, including draftsmen (33,000), and inventors (2,400). In 1920 there were 207,000 engineers, including draftsmen (53,000), and inventors (2,400). This is an increase of more than 50 per cent in the number of engineers. The allied profession of architecture numbered 16,600 in 1910, and 18,200 in 1920. A part of the draftsmen above enumerated is assignable to architecture, but the census gives no means of enumerating the percentage.

Civil engineers and surveyors comprise about one-third of all the engineers and draftsmen, but since a large percentage of the draftsmen are assignable to the civil engineering profession, it is probable that nearly 40 per cent of all engineers and draftsmen are doing civil engineering work, that is designing, constructing and maintaining roads, streets, sewers, waterworks, railways (steam and electric), and industrial or commercial building.

The number of engineering students enrolled last year in our engineering colleges is startlingly large—53,414. Of these, 16,000 were enrolled in civil engineering courses, 12,000 in mechanical, 12,000 in electrical, and 2,700 in mining. There were only 1,000 students taking architecture.

It would seem at first sight that the engineering profession will soon be badly overcrowded, and it would be, were the old, narow conceptions of engineering still prevalent. Engineering is no longer regarded as being confined to the designing of structures and machines. According to the present conception, engineering is the systematic application of science to the problems of economic production, transportation and service. Under this definition the field of engineering is almost limitless, and overcrowding of the profession is a thing that is not apt ever to occur.

Variation in Strength of Concrete with Age

Several years ago the Texas Portland Cement Co. submitted to the Bureau of Economic Geology and Technology of the University of Texas samples of the cements produced by the Houston and Dallas mills for tests extending over a long range of time. Tests of these cements are given in a recent progress report of the Engineering Research Division of the Bureau. The variation with age in the compressive strength of concrete cylinders made with these two cements is shown in the following table, in which each value is an average of the results for five cylinders:

7 days.	28 days.	3 mo.	6 mo.	1 yr.	2 yr.	5 yr., 4 mo.
1,570	2,830	3,400	3,180	3,110	3,260	3,740
1,775	3,565	3,310	3,305	2,995	3,025	3,390

The mix employed for these concrete cylinders was 1:2:4 by loose volume, using Ottawa sand for the fine aggregate and crushed limestone, graded from ¼ to 1¼ in., for the coarse aggregate. Water used was 8.4 per cent by weight of the dry materials. Cylinders were stored in damp sand for six days and then in the air of the laboratory until tested.

Book Review

Building Labor Calculator—By Gordon M. Tamblyn. Published by the Western School of Estimating and Plan Reading, Denver, Colo.

This work consists of an introductory chapter and a set of tables, all printed on loose-leaf sheets, 3¾ in. x 7 in., and carried in a three-ring binder. The introduction reprinted elsewhere in this issue, gives concise and important directions for efficient and accurate estimating. The tables give quantities of materials and labor for different units of construction and include numerous explanatory notes.

The labor tables are in the form of hours of labor per unit of material, and are much the most complete that we have seen. In use, the total quantities of material multiplied by the labor factors or "constants" give the total hours of labor necessary. As an example, we quote from the table on "Finish Carpentry." Three columns are provided for this class of work—carpenter, laborer, foreman. For the fitting of each single window frame, the constants for each of the three labor items, are, .70, .20, .10. For "four member cornices, ordinary," the contants are given per lineal foot, as follows: .25, .02, .02. There are three pages to this table of Finish Carpentry.

In the introduction the author points out that while special and local conditions will cause minor variations from these constants, the figures represent fair averages which may be relied upon under ordinary circumstances.

The Revised Index Numbers—Changes in Weightings and Classifications

Space limitations prevent the publication in these columns of complete data covering the classification of commodities and the weightings employed in the U. S. Bureau of Labor Statistics' calculation of index numbers of wholesale prices.

As stated in our issue of June 28, the old index was based on 327 commodities at the time of its discontinuance on May 1 last. The commodities used had varied slightly from time to time. The revised index is based upon 404 commodities.

Basis of Original Index.—The old index was based upon the total quantity of each commodity sold in the year 1909 as nearly as those quantities could be determined; the index for any period being calculated by taking a total made up of the products of every commodity quantity multiplied by the average price of the commodity for the period, and dividing this total by a total similarly calculated for the year 1913. Thus 1913 became the 100 per cent base year for which the index of all commodities and of each group was calculated.

The Revised Index.—The revised index is similarly calculated except that the quantities used are those of the year 1919 instead of 1909, and except also for certain details in the calculation of the various group indices as noted in mimeographed form No. 1531 of the Bureau of Labor Statistics as follows:

"In preceding reports of the Bureau the plan was followed of confining an article to a particular group, regardless of its fitness for inclusion also under other group designations. With the new plan articles properly falling under more than one of the classifications adopted have been included under each classification. For example, structural steel, nails and certain other metal products used in building have been put in the group of building materials as well as in that of metals. Similarly, food articles produced on the farm that reach the consumer practically unchanged in form, as potatoes, rice, eggs and milk, are included both among farm products and among foods. In computing the general index number for all commodities, however, such articles have been counted only once, thereby avoiding duplication in the final result. A transfer of an article to a different group has been made in a few instances in revising the classification of commodities."

From the foregoing it should be evident that the changes in the index have resulted from the addition of a number of new commodities to the list used, from the regrouping of commodities, and from the use of quantities sold in the year 1919 instead of in 1909. In some instances the regrouping and the additions have produced no large effect on final results; and for the most part the changes in commodity quantities have not been great. We shall here consider the changes in only the two groups in which civil engineers and contractors have the most direct professional interest—metals and metal products, and building materials.

The Metals Index.—The metals and metal products index shows relatively unimportant variations until the latter part of 1915. In January, 1916, the revised exceeded the old index by 7 points, or about 5½ per cent, and by July, 1917, the difference reached 35 points, or nearly 14 per cent. This was the maximum variations, and in July, 1921, the revised index began to fall below the original. In April, 1922, it was 4 points lower.

A comparison of the items and quantities of the two indices is as follows:

TABLE 1.

	Units.	(000 omitted in each case.) Old index 1909quan tities.	Revised index 1919quan-tities.
Iron ore, lower lake ports—			
Mesabi, Bessemer, 55%	Gross ton	52.310	21,355
Non-Bessemer, 51½%	Gross ton	....	35,440
Pig iron—			
Basic, valley furnace	Gross ton	1,742	4,541
Bessemer, Pittsburgh	Gross ton	1,168	2,920
Foundry No. 2, Pittsburgh	Gross ton	2,557	748
Foundry No. 2, Birmingham	Gross ton	2,557	748
Feromanganese, seaboard	Gross ton	....	218
Spiegeleisen	Gross ton	....	84
Bar iron—			
Best refined. Philadelphia	Lb.	1,083,265	*506,373
Common, Pittsburgh	Lb.	1,083,265	*506,373
Bars, reinforcing, Pittsburgh	100 lb.	....	*6.751
Nails, wire, Pittsburgh	100 lb.	13.916	13,094
Pipe, cast iron, 6 in., New York	Net ton	1,146	703
Skelp, grooved, Pittsburgh	100 lb.	....	*57,994
Steel billets, Pittsburgh—			
Bessemer	Gross ton	4.972	1.320
Open hearth	Gross ton	....	4,908
Steel, merchant bars, Pittsburgh	100 lb.	....	*88,370
Steel tank plates, Pittsburgh	Lb.	5,256,756	*9,648,128
Steel rails, Pittsburgh—			
Bessemer, standard	Gross ton	1,767	*214
Open hearth, standard	Gross ton	1.257	*1,893
Steel sheets, black, Pittsburgh	Lb.	....	*5,130,944
Structural steel, Pittsburgh	100 lb.	49,969	56,617
Terneplate, Pittsburgh	Box	....	854
Tin, plate, Pittsburgh	100 lb.	12,968	*24.076
Wire, barbed, galv., Chicago	100 lb.	6,471	6,823
Wire, plain fence, Pittsburgh	100 lb.	9,580	11,849
Aluminum, New York	Lb.	....	*159,176
Copper, ingot, refinery	Lb.	1,312,438	*1,805,307
Copper, sheet, New York	Lb.	....	*105,400
Copper wire, bare, mill	Lb.	278.964	*323,320
Lead, pig, New York	Lb.	732,153	*964,440
Lead pipe, New York	100 lb.	1,058	932
Quicksilver, New York	Lb.	....	2,404
Silver, New York	Ounce	151,969	*56,682
Tin, pig, New York	Lb.	94,248	89.665
Zinc, sheet, factory	100 lb.	573	1,086
Zinc, slab, New York	Lb.	464,903	*931,486

*Complete analysis of the difference in indices is a lengthy process which will not be attempted here, as the major part of the difference is traceable to a few items. Inspection of the table shows that the quantities, and consequently the relative index weights, of many iron and steel products are greatly increased in the new index.

It so happened that the greatest price advance from 1913 to July, 1917, was in this very group, and the increase in the weight of these items accordingly raised the index. Prices of these commodities were much reduced, as will be remembered, soon after this country's entrance into the war.

A rough calculation of the effect of the change from quantities of 1909 to quantities of 1919, shows that for 10 of the largest items in the iron and steel list, plus also aluminum and copper, the increase in quantities resulted in an increase of $1,400,000,000 in commodity values. This increase is net, and allows for reductions of quantities of bar iron and Bessemer rail. The most important changes were in skelp, merchant bar, tank plates, and steel sheets; the increases in the prices of which ranged from 230 to 500 per cent. Skelp and merchant bar, which were not included in the old index, total roughly $200,000,000 at 1913 prices and $800,000,000 at prices of July, 1917. The price of tank plate rose from 1½ ct. per lb. in 1913 to 9 ct. per lb. at the 1917 peak, which, coupled with the great increase in quantity, made a decided effect on the index.

Building Materials Index.—Conspicuous variations in this index began early. Up to the middle of 1915 the revised index was generaly lower than the original. From then on, there were fluctuations, sometimes one and sometimes the other being the larger. In May, 1917, the revised index was 42 points, or 36 per cent, greater than the old, while in June, 1920, it was 62 points, or about 18 per cent below the latter. The peaks of both indices occurred in April, 1920. In October, 1920, the new was 73 points lower than the old, and has since remained lower by varying amounts, the difference being 45 points, or 22 per cent, in December, 1921, and also in April, 1922.

A comparison of the items and quantities of the two indices follows:

Portland Cement Association, 111 West Washington St., Chicago.

TABLE 11.

	Units.	Old index 1909 quan-tities.	Revised index 1919 quan-tities.
		(000 omitted in each case.)	
Douglas Fir—			
No. 1 common	1,000 fbm	3,642M	4,427M
No. 2 and better	1,000 fbm	1,214M	1,476M
Gum	1,000 fbm	....	851S
Hemlock	1,000 fbm	3,051N	1,755C
Maple, hard	1,000 fbm	1,107N	858C
Oak, white, plain	1,000 fbm	1,471N	2,708O
Oak, white, quartered	1,000 fbm	2,943N	....
Pine—			
White, No. 2 barn	1,000 fbm	3,510N	1,724B
White, rough uppers	1,000 fbm	390N	....
Yellow, flooring	1,000 fbm	10,173N	4,898M
Yellow, siding	1,000 fbm	6,104V	....
Yellow, timbers	1,000 fbm	....	8,165M
Poplar	1,000 fbm	859N	350O
Spruce, eastern	1,000 fbm	1,749N	980M
Lath, yellow pine, No. 1	1,000	....	2,674M
Lath, eastern spruce	1,000	4,388N	....
Shingles, cypress, 16 in.	1,000	1,387M	1,182M
Shingles, red cedar, 16 in.	1,000	12,005M	10,258M
Brick, common	1,000	....	4,553a
Chicago	1,000	3,264C	....
Cincinnati	1,000	3,264O	....
New York	1,000	3,264N	....
Structural steel	100 lb.	....	56,617P
Cement, Portland	Bbl.	65,435M	86,141e
Crushed stone, 1½ in.	Cu. yd.	....	27,200N
Gravel	Ton	....	34,607
Hollow tile, building	Block	....	264,050C
Lime, common lump	Ton	....	3,071
Lime, eastern, common	Bbl.	23,278p	....
Sand, building	Ton	....	21,970s
Slate, roofing	100 sq. ft.	....	454q
Glass, plate—			
3 to 5 sq. ft.	Sq. ft.	24,861N	28,808N
5 to 10 sq. ft.	Sq. ft.	24,861N	28,808N
Glass, window—			
Single A	50 sq. ft.	3,461p	3,689p
Single B	50 sq. ft.	3,461p	3,689p
Linseed oil, raw	Gallon	102,528N	62,536N
Putty, commercial	Lb.	63,502N	66,682N
Rosin, common to good (B)	Bbl.	3,673N	2,272N
Turpentine	Gallon	29,765N	19,271N
White lead, in oil	Lb.	247,237N	237,359N
Zinc oxide	Lb.	143,550N	279,321N
Pipe, cast, iron, 6 in.	Net ton	....	703N
Copper, sheet	Lb.	....	105,400N
Copper wire	Lb.	....	323,320M
Lead pipe	100 lb.	....	932N
Nails, wire	100 lb.	....	13,094P
Reinforcing bars	100 lb.	....	6,751P
Roofing tin	200 lb.	....	854P
Zink, sheet	100 lb.	....	1,086p

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m at mill.
N at New York.
V at Norfolk, Va.
S at St. Louis.
C at Chicago.
O at Cincinnati, O.
B at Buffalo, N. Y.
M at Boston, Mass.
a simple average of 82 yard prices.
e simple average of 6 plant prices.
t average of 22 plant prices.
l average of 15 plant prices.
p at plant
s average of 26 plant prices.
P at Pittsburgh.
q at quarry.

Variations between the old and the new indices in the case of this group of commodities are traceable to two major sources—the shifting of lumber quotations from New York to more representative locations, and the addition of structural steel and the group of metal products shown at the end of the list. No attempt will be made here to analyze the difference in detail, but it is of interest to note the most important of the changes and their causes.

The quantities used are for the entire United States, while prices of necessity are limited to a few points. The New York prices used for most of the lumber in the old index were not representative of the country as a whole, and contributed to the imperfection of the index. Likewise the addition of large quantities of structural steel, reinforcing bars, nails, copper sheets and copper wire, largely increased the index in 1917, as the discussion of the metals index shows. These same commodities later reduced the index, as for some time they have been below the general average of other building materials. These facts are shown in the tabulation following:

	July, 1917.	May, 1920.	April, 1922.
Old index, all building materials	132	341	201
New index, all building materials	168	293	156
Index of structural steel	387	213	99
Index of reinforcing bars	...	231	109
Index of wire nails	225	225	138
Index of copper sheets	189	139	91
Index of copper wire	202	137	88

The Weight of Each Group in the Index of All Commodities.—We have not at hand any statement of the group weights under the revised index, or under the old index subsequent to 1919; but we take from Appendix B of Bulletin No. 269, of the U. S. Bureau of Labor Statistics, a tabulation showing the weights or percentages of the old index for 1909 and 1919. It should be kept in mind that the calculations for both these years are based upon quantities of 1909, only the prices changing for the 1919 calculation. In addition to what is here reproduced, the appendix gives the value of each commodity as a percentage of its group, and as a percentage of the value of all commodities.

	Percentage of commodity values.	
	1909.	1919.
Farm products	27.58	28.14
Food, etc.	26.34	24.45
Clothes and clothing	11.23	14.26
Fuel and lighting	10.32	8.70
Metals, etc.	5.67	6.20
Building materials	11.47	9.73
Chemicals and Drugs	1.24	1.13
House furnishings	0.42	0.51
Miscellaneous	5.72	6.87
All commodities	100.00	100.00

While the new index is obviously imperfect, it represents a decided improvement over the old. Probably the most conspicuously questionable item of the building material group is that of copper wire, of which only a very small part of the total production is used in buildings. Six-inch cast iron pipe is another item which is in large part not assignable to building materials. If it were desired to make this group an index of all construction, then not only wire and pipe, but such commodities as railroad rails, should be included.

Cold Weather Concreting in Construction of Hide and Leather Building, New York

The erection of the Hide and Leather Building, New York City, the highest all-concrete building in the United States, again demonstrated the feasibility of carrying on concrete construction during the winter months. The methods of protecting the concrete are described as follows in the National Builder:

The first floor was completed in October, 1920, and the sixteenth floor was completed four months afterwards. During this period fifteen complete working days were lost on account of inclement weather. Thus one floor was poured every six calendar days.

The method employed to facilitate the pouring and prevent frozen concrete proved thoroughly efficacious.

As soon as construction had reached the first floor, the latter was adequately shored, to enable it to bear the load which it was to be called upon to sustain. Planking was now laid down, upon which a system of perforated steam pipes (about 12-in. centers) was arranged. These pipes served to warm the aggregates stored on this floor, which usually held enough material to pour two whole floors, or about 600 yd. By means of suitable valves the steam could be turned off or on at will in any way desired. Planks placed between the pipes enabled trucks to drive over the pipes without damaging them. The material was wheeled from the piles as needed and pumped into a hopper, through which it fell directly into the mixer in the basement, which had been set up in what was to be the elevator shaft of the building.

Up this shaft ran the usual wooden hoist tower, the mixed aggregate being drawn up in the customary bucket. The adoption of the chute system proved a great help in facilitating the work of pouring, because of the small floor space (the plot is only 70x80 ft.). Thus it was possible to pour concrete over the heads of men working on the floor and so prevent crowding, which would have ensued had the concrete been transferred in buggies.

A water tank was constructed capable of supplying sufficient water, without replenishing, for the preparation of four or five batches of concrete. This water was kept almost at the boiling point by the introduction of live steam and thus the concrete reached the forms steaming hot.

Immediately after a bay had been poured 4x4's were set down, sloping from the surface to the dowels of the columns, and specially prepared tarpaulins were battened down. Further, a hole cut in the steel slab form in the center of each bay, with a box built over it, permitted the heat from the salamanders to circulate between the canvas and the concrete surface. As a further precaution heavy tarpaulins were hung over the outside walls of the building and additional salamanders installed just inside the walls. A thermometer registering maximum temperatures was on the job and both these temperatures were noted in the daily report to the office. In addition, wooden-enclosed thermometers, similar to those used in bathtubs, were set about the job and the concrete foreman was constantly reading the temperature of the fresh concrete. These measures proved so effective that there was not a single instance of frozen concrete.

Index Numbers of Wholesale Prices Jan. 13, to June 1922

The accompanying tabulation shows the revised index numbers of wholesale prices by groups of communities as computed by the U. S. Bureau of Labor Statistics. Revised index numbers for each year from 1890 to 1913 are now in preparation by the Bureau, and will be published in this column as soon as they are available.

The group of miscellaneous commodities includes such important articles as leather, cottonseed meal, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, starch, tobacco, Manila hemp, sisal and wood pulp. The commodities, composing the other groups, are as indicated by the titles.

The new index numbers and the following explanations are from Bureau of Labor Statistics, Form 1531:

The weighting of the prices used in constructing the index numbers for the different groups of commodities by the new 1919 census figures of production, instead of the 1909 data used in preceding reports, conforms to the plan contemplated by the Bureau at the inception of its weighted index number system in 1914 of revising the weighting factors every ten years as new census information should become available. All computations have been carried back to 1913 in order to insure comparability of the figures and also to provide a pre-war standard for measuring wholesale price changes.

The following table gives the revised index numbers for the several commodity groups from January, 1913, to the latest month for which complete information is available. For comparison with the new series, the old general index of all commodities is shown in the last column of the table. Publication of the old series was suspended with the April, 1922, figures.

REVISED INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES AND BY MONTHS, 1913 TO 1922 (1913 EQUALS 100).

	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	All commodities. New Index.	All commodities. Old Index.
1913	100	100	100	100	100	100	100	100	100	100	100
Jan.	98	99	99	100	107	101	100	100	106	100	100
Feb.	98	98	100	101	105	102	101	100	105	100	100
Mar.	98	98	100	101	105	103	101	100	103	100	99
Apr.	99	98	100	98	104	103	101	100	100	100	98
May	97	97	100	98	103	103	100	100	98	99	98
June	98	99	100	98	101	102	100	100	100	99	100
July	99	101	100	99	98	99	100	100	100	100	100
Aug	100	102	100	101	98	99	100	100	98	100	101
Sept.	103	103	101	101	98	99	100	100	100	102	102
Oct.	103	102	101	102	97	98	100	101	98	101	101
Nov.	103	103	101	102	91	97	100	100	97	100	101
Dec.	103	101	100	99	89	96	98	100	96	99	99
1914	103	102	98	93	85	92	101	100	95	98	100
Jan.	103	101	99	99	88	93	98	100	94	98	100
Feb.	103	100	99	99	89	94	98	100	96	99	99
Mar.	102	98	99	100	89	94	98	100	98	98	99
Apr.	102	95	99	98	88	93	97	100	98	98	98
May	101	96	99	95	85	93	97	100	99	97	98
June	101	97	99	91	84	93	96	100	95	97	99
July	103	99	99	91	83	92	95	100	93	97	100

	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	All commodities.	
										New index.	Old index.
Aug.	106	109	99	89	84	93	96	100	94	101	103
Sept.	106	111	97	89	86	92	109	100	96	102	104
Oct.	101	106	96	88	83	90	108	100	92	97	99
Nov.	102	106	94	88	89	88	107	100	91	97	98
Dec.	101	105	94	88	81	88	107	100	96	97	98
1915	104	105	98	88	99	94	134	100	95	101	101
Jan.	104	106	94	87	82	88	108	99	99	98	99
Feb.	105	108	95	86	86	89	116	99	93	99	101
Mar.	104	106	95	84	88	90	118	99	93	99	99
Apr	104	105	96	82	90	90	118	99	93	99	100
May	105	105	96	82	96	93	116	100	93	100	101
June	101	102	96	81	102	93	123	100	93	99	99
July	104	104	36	81	106	94	130	100	94	100	101
Aug	103	102	97	85	103	93	136	100	93	100	100
Sept.	101	99	99	91	101	94	143	100	92	100	99
Oct.	106	102	101	94	105	98	151	100	93	102	101
Nov.	104	106	105	98	110	101	165	100	95	104	103
Dec.	105	108	107	103	122	104	179	101	100	108	106
1916	123	121	127	126	162	120	181	106	121	127	124
Jan.	110	109	110	113	133	110	184	103	110	113	110
Feb.	110	110	114	115	142	113	204	103	105	115	112
Mar.	111	112	117	119	156	118	206	104	108	119	114
Apr.	113	114	118	120	164	120	200	104	110	121	117
May	115	115	120	120	168	121	193	105	114	122	118
June	114	115	122	122	164	120	191	105	120	123	119
July	117	117	125	121	158	120	175	107	120	123	119
Aug.	125	122	128	116	157	120	157	107	121	126	123
Sept.	131	126	130	120	160	121	158	107	124	130	128
Oct.	136	134	137	128	164	124	164	109	132	136	134
Nov.	147	141	147	155	174	126	167	111	139	146	144
Dec.	146	137	154	163	199	132	172	111	147	149	146
1917	190	167	175	169	231	157	202	125	148	177	176
Jan.	152	140	158	171	198	138	173	118	149	153	151
Feb.	157	145	157	178	204	140	173	119	150	157	156
Mar.	166	148	158	174	218	144	181	120	151	162	161
Apr.	184	164	164	164	230	155	186	121	153	173	172
May	196	175	167	178	240	159	194	121	151	183	182
June	195	171	174	183	267	169	195	123	153	185	185
July	196	169	181	176	292	168	205	129	153	188	186
Aug.	202	175	186	167	282	167	211	129	150	180	185
Sept.	202	176	185	160	260	167	223	130	147	187	183
Oct.	207	180	185	153	207	156	231	130	142	183	181
Nov.	212	181	191	161	183	156	223	131	140	183	183
Dec.	207	181	195	163	183	158	228	133	140	182	182
1918	218	188	228	170	187	172	215	153	156	194	196
Jan.	211	182	201	164	183	161	223	137	145	184	185
Feb.	211	183	205	164	184	161	227	138	145	186	186
Mar.	211	179	211	165	184	164	229	140	147	187	187
Apr.	213	181	220	166	184	169	228	144	152	190	190
May	209	180	226	169	185	170	222	146	155	190	190
June	210	180	233	169	184	172	205	152	160	191	193
July	217	185	238	175	189	177	209	159	159	196	198
Aug.	227	189	239	175	190	179	212	161	160	200	202
Sept	234	195	245	176	190	179	210	163	161	204	207
Oct.	225	198	245	176	192	177	211	164	163	202	204
Nov.	225	204	241	179	191	177	209	164	164	203	206
Dec.	227	206	233	179	187	177	194	163	163	202	206
1919	231	207	253	181	162	201	169	184	175	206	212
Jan.	224	203	220	178	175	176	181	167	166	199	203
Feb.	216	194	210	178	170	173	169	165	163	193	197
Mar.	224	199	203	178	163	171	162	164	161	196	201
Apr.	230	205	205	177	153	169	160	167	160	199	203
May	234	210	216	178	153	173	161	168	161	202	207
June	226	204	243	180	154	189	162	180	167	203	207
July	241	210	262	181	160	209	167	183	177	212	218
Aug.	242	214	276	184	162	226	170	188	187	216	226
Sept.	225	205	283	188	161	229	170	190	189	210	220
Oct.	227	205	291	189	162	229	173	194	187	211	223
Nov.	237	210	304	188	164	232	176	217	189	217	230
Dec.	242	220	317	189	168	248	182	222	189	223	238
1920	218	220	295	241	192	264	200	254	196	226	243
Jan.	247	231	339	194	175	274	189	239	194	233	248
Feb.	237	222	346	199	190	293	195	242	197	232	249
Mar.	237	220	344	208	197	297	205	242	200	234	253
Apr.	243	238	336	231	203	300	210	242	206	245	265
May	241	248	328	239	202	293	213	247	208	247	272
June	237	243	314	250	200	275	212	248	205	243	269
July	233	238	300	259	202	269	212	275	203	241	262
Aug.	218	221	286	269	202	265	209	274	199	231	250
Sept.	210	215	266	281	200	255	205	273	195	226	242
Oct.	187	201	245	280	191	240	198	271	188	211	225
Nov.	173	190	226	264	176	215	181	260	179	196	207
Dec.	152	170	215	254	160	204	164	242	166	179	189
1921	124	144	180	199	129	165	136	195	128	147	153
Jan.	143	162	196	247	153	192	153	217	154	170	177
Feb.	133	151	188	225	147	180	149	217	147	160	167
Mar.	127	151	183	212	140	173	143	216	139	155	162
Apr.	117	144	176	205	138	167	135	216	130	148	154
May	118	139	173	200	138	165	134	209	126	145	151
June	114	137	172	191	133	163	133	196	125	142	148
July	119	141	172	186	124	160	129	180	123	141	148
Aug.	123	146	171	184	117	156	129	179	119	142	152
Sept.	124	142	178	181	116	156	131	179	118	141	152
Oct.	124	140	180	189	116	159	131	180	118	142	150
Nov.	121	139	180	197	114	163	129	178	119	141	149
Dec	120	136	180	199	113	158	127	178	121	140	149
1922											
Jan.	122	131	176	195	112	157	124	178	117	138	148
Feb	131	135	174	191	110	156	123	177	117	141	151
Mar.	130	137	172	191	109	155	125	175	117	142	152
Apr.	129	137	171	194	113	156	124	175	116	143	152
May	132	138	175	216	119	160	122	176	116	148	...
June	131	140	179	225	120	167	122	176	114	150	...

Civil Service Examination for Senior Architect.—The U. S. Civil Service Commission has announced open competitive examinations for senior architect and senior engineer, grade 2, to fill vacancies in the Interstate Commerce Commission. Salaries range from $2,100 to $2,700 per year.

Electrical and Magnetic Weld Testing of Butt-Welded Steel Plates

A series of laboratory tests applied to arc butt-welded steel plates to determine the possibility of developing electrical and magnetic tests that will be capable of revealing the quality of such welds were described by T. Spooner and I. F. Kennard in a paper presented June 28 at the annual meeting of the American Society for Testing Materials.

The tests were made on four steel plates which were butt welded by an experienced operator:

	Thickness. In.	Length of weld. In.
Plate A	½	16
Place B	¼	24
Plate C	¼	24
Plate D	½	24

The joints were made according to a predetermined schedule and were designated by the welder as good, fair and poor over various sections.

The method of application was similar for the electrical and magnetic methods of test and consisted in measuring the electrical or magnetic potential drop across the weld with a definite e.m.f. or magnetic potential applied on opposite sides of the weld. This drop was compared with the drop over an equal length of unwelded plate. The e.m.f. or magnetic potential was applied at points fairly close to the weld in order to localize the effect. If the e.m.f., for instance, had been applied at the edges of the plate parallel to the weld, the current would have distributed itself inversely as the resistivity and the potential drop across the various portions of the weld would have been nearly the same regardless of the quality.

After completing the electrical and magnetic tests the plates were cut into strips 1 in. wide at right angles to the welds and these strips tested for tensile strength.

The electrical, magnetic and tension tests showed a very fair general agreement among themselves and with the known quality of the welds as reported by the welder. The electrical and magnetic tests tended to smooth out small local defects, thus giving an approximation of the average quality of the weld over a distance of several inches. In other words, the variations by these tests were not as great as shown by the tension tests but are perhaps just as good an indication of the quality of the weld as a whole.

The conclusions of Messrs. Spooner and Kinnard are summarized as follows in the paper:

It would seem that the tests will pick outs faults in welds irrespective of what type they may be. For instance, it was brought out by an examination of the test strips that a small cross-section at the weld shows up magnetically. On the other hand, if there is a surplus of metal at the weld and part of it poor, this condition is detected.

From the experimental work here reported it seems that the magnetic methods give the more consistent results

For butt-welding it is quite feasible to definitely state from the magnetic test whether a weld is good, fair or poor when the results are properly interpreted.

While the electrical or magnetic tests do not detect small isolated bad spots with certainty, a fairly poor weld extending over considerable distance will be indicated without the slightest possibility of doubt.

It is apparent that the tension tests indicate much poorer quality of welds than the magnetic or electrical. However, from considerations mentioned above we believe that the tension tests indicate a poorer quality than actually exists while the electrical and magnetic tests show more nearly the average quality.

All of the welds with the exception of plate A, would be considered good average welds. For this plate, the tension, magnetic and electrical tests all agree that this is a poor weld.

It should be possible to readily devise a simple and portable apparatus for applying these methods, especially the magnetic, for commercial weld testing. The magnetic method should be more readily applicable since actual metallic contact between the testing apparatus and the plate is not essential.

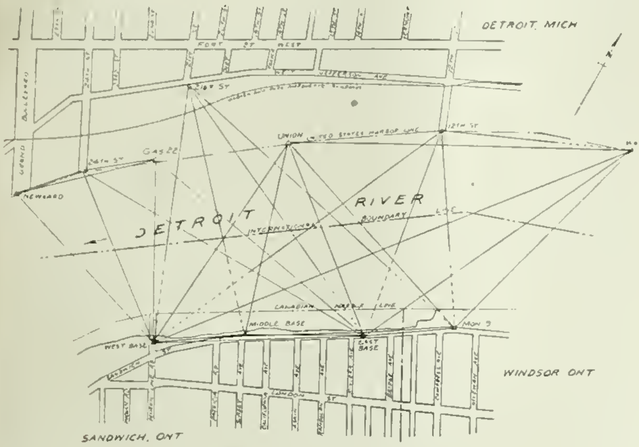
These results open up a line of approach to weld testing in general. It remains to be seen whether the foregoing methods can be successfully applied to lap-welded joints and other untried forms. The application to butt welding alone should be quite important to any industry that utilizes this type of weld extensively.

Detroit River Triangulations for Fixing Span Length of Detroit-Windsor Bridge

By H. F. JOHNSON.

Junior Assistant Engineer, U. S. Lake Survey.

The work of the United States Lake Survey was begun in 1841 and the main geodetic work, consisting of accurate triangulations and levels was completed in 1882. The organization, however, has been since maintained to perfect and extend this work, and to continue hydrographic work as has been done on the Ocean and Gulf Coasts by the Coast and Geodetic Survey. The Boundary Survey by the United States and Canadian governments also made extensive geodetic surveys from 1908 to 1913.



Triangulation Detroit River Between Sandwich, Ont., Windsor, Ont., and Detroit, Mich.

The Canadian Government has also established harbor lines along the Detroit River in front of the Border Cities, fixing them by means of offsets from waterfront street intersections, and by the courses of the separate lines. The City of Detroit has established harbor lines in the same manner, under approval from the War Department. These harbor lines had not, however, been connected either by the Lake Survey or Boundary triangulations, and when it became necessary to determine the exact width of the river for the Detroit-Windsor Bridge, it was first done in a rough manner by a careful replotting of the harbor lines by coordinates. This was not accurate enough for the final location of the tower piers, which are over 1,800 feet center to center, so it was decided to make accurate triangulations connecting the angle points of the American and Canadian harbor lines and determine—

First—The accurate relative positions of the harbor lines on the two sides of the river.

Second—Accurate fixed points on both sides of the river to use in future surveys of the river and in the bridge location.

Third—The accurate relative positions of the street systems of Detroit and of the cities on the Canadian side.

The means of doing this was an agreement between the U. S. Lake Survey and the Detroit-Windsor Bridge Co. for mutual co-operation in doing the work, the expenses being borne by the bridge company. The writer obtained a furlough and took charge of the party organized by the bridge company, using the methods of the Lake Survey.

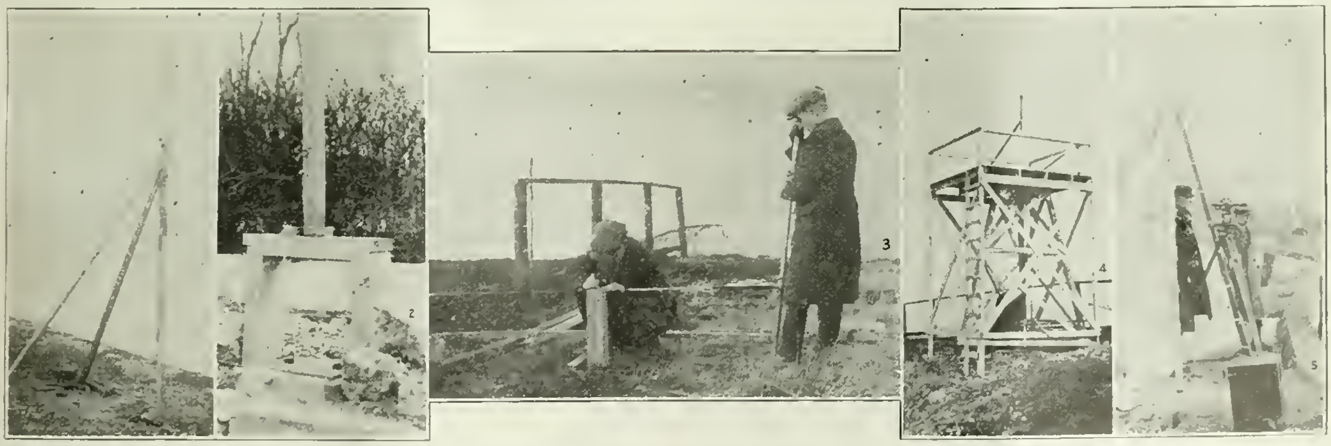
A site for a base line could not be found on the Detroit side, but on the Canadian side was a paved street, running not far from the river about 20 ft. above its level, and with no buildings between the street and shore. However, it was not straight and a straight line of sufficient length would cross the street twice on long diagonals, thus giving trouble in placing and holding the tape supports. To avoid this a line was chosen, with a slight angle, so that most of the length of each part came just back of the curb on the river side of the road.

At the west end of the base, the line left the curb and ran to a point chosen for west base on the east side of Huron Church Line road. At the east end of the base, the line crossed the road at such an angle that only three tape supports were necessary on the pavement.

The east end of the base is 1,441.36 ft. and west end 1,090.32 ft., a total of 2,531.68 ft. This reduced to a straight line between E. Base and W. Base, which points were intervisible, is 2,530.45 ft. The end stations are marked by good concrete monuments, with crosses cut on top of inserted copper bolts. Middle Base was marked by a 3 in. iron pipe, filled with concrete and with a copper bolt like the others. The final length as given will have a probable error of about one in five hundred thousand.

The tripod used to set the instrument on was made of 4 in. x 4 in. pine posts set in the ground, with considerable batter and well braced on all three sides to insure stability. The tops were cut off level and a suitable distance apart to receive the legs of the theodolite or instrument tripod. The observers' platform was built outside of and surrounding this tripod, but entirely separate from it, to prevent any movement of instrument while observing, four 2 in. x 4 in. posts well set in the ground were used and securely braced.

The targets used were flat pine strips about 1 in. x 2½ in. section, the edges being beveled at an angle of about 45° with the face to prevent phase, the wide face being used for sighting upon. These targets are covered with alternate strips of white and black cloth tacked over the wide face and edges.



(1) Site Pole at Temporary Stations, (2) Site Pole Over Permanent Stations, (3) Baseline Invar Tape Showing Method of Obtaining Tension, (4) Instrument Tripod and Observers Platform, (5) Shelter Tent for Observers.

The target over permanent monuments was of the type described above, but also had a temporary base consisting of three pieces of 2 in. x 4 in. nailed over the top of the concrete monument; on the top of which a copper strip was placed with a point scratched on it, exactly over the corresponding point on the copper bolt in the monument. This was used for the base line measurements.

The shelter tent for the observer, consisted of a tripod made by hinging three wood strips together at top, by a bolt passing through all three legs and covered with canvas on two sides. This canvas was in two sections, one piece extending from a short distance below ordinary height of instrument to ground with flap at bottom to weight canvas down. The second piece of canvas extends above top of instrument and is so arranged that a portion of it can be drawn aside to obtain sights in other directions when necessary.

The tape supports were 4 in. x 4 in. posts set well in the ground, except the three on the pavement, which were braced posts with cross pieces which could be placed by means of marks scratched on the pavement. Whenever these were used they were weighted to hold them in place during the measurement and removed immediately afterward.

The height of the supports for the ends of the tape were about 1 ft. The supports for the middle of the tape had their front sides on line and enough higher than the grade line to have a nail driven in, to which was hung a wire hook to support the tape. The tape used was a 50-meter invar standardized tape, with only the 0 and 50-meter points marked. The two portions of the base line were not of even tape lengths as their ends were fixed within narrow limits by other considerations. That part of each portion of the base not possible to measure with the invar tape was measured with a steel tape which has been sent to the Bureau of Standards at Washington to have determined the standard length between the marks used. Copper plates of the thickness of the beads on the 50-meter tape were nailed on tops of tape end posts with one edge on the transit line between base marks. These copper strips were numbered and after base line measurements were made, they were carefully removed and nailed in the same relative position on a strip of wood; using a centimeter scale for distances, and from them measurements were checked. Tension of 15 kilograms was applied to the tape during measurements. The tape stretcher used for obtaining the proper tension in the tape, consists of a steel bar about 5 ft. long, sharpened at one end, with sliding collar adjustable at any height, and to which a spring balance reading to kilograms is attached. Set-backs when necessary were made with a pair of dividers set on an accurate centimeter scale. Each time of the four times measurements were made over the base, a new set of marks were made by starting with a different set-back.

From the base was developed a small system of triangulation connecting toward the east to old stations of the U. S. Lake Survey. The angles were read by the repeating method with a 10-second transit, with 8-in. circle and three leveling screws. Care was taken to have all targets set plumb and on center. At each of the ten stations, an angle was read to close the horizon and the average closing error was 2.5 seconds. There were 17 triangles in which all three angles were read, and the average closure was 2.1 seconds, but if the eight principal triangles only are taken, the average closure is less than one second. The resulting distance across the river should be correct within ⅛ in. Points which will fix the harbor lines on both sides of the river were determined by the triangulation. The relative positions of the center lines of principal streets in Detroit and on the Canadian side were carefully determined.

The field work and computations were made under the writer's direction, and the final mapping under J. A. Stilson, Right of Way Engineer for the Bridge Company. The U. S. Lake Survey is in charge of Col. E. M. Markham, Corps of Engineers, U. S. A., and F. G. Ray, Principal Assistant Engineer in direct charge. The work for the Bridge Company was in charge of C. E. Fowler, Second Vice President and Chief Engineer of the Detroit-Windsor Bridge. The permanent base line and triangulation stations become the property of the U. S. Lake Survey, but are available throughout the construction of the bridge for the use of the American Transit Co., owners of the bridge.

Accidents in Building Construction in California.—The following tabulation shows the number of fatal, permanent and temporary injuries sustained by workers engaged in building construction in California during the calendar years 1917, 1918, 1919 and 1920:

	Number of injuries			
Industry.	Year.	Fatal.	Permanent.	Temporary.
Building construction	1917	47	192	7,917
Bulding construction	1918	37	107	5,791
Building construction	1919	41	124	5,811
Building construction	1920	42	187	11,020
Total		167	610	30,539

There were 37 fatal injuries in 1921.
There were 12 fatal injuries up to April 15, 1922.

How to Eliminate Waste in Construction Industry

Practical Suggestions for Large Savings, Outlined in Paper Presented June 20, at the Organization Meeting of the American Construction Council

By D. KNICKERBACKER BOYD,
Standardist, Philadelphia.

I will go somewhat into detail concerning features of waste in the construction industry which, as I see them, can and should be eliminated.

It can be conservatively estimated that the American Construction Council, properly functioning through local groups, may be able to save the American people one billion dollars through the elimination of these and other preventable wastes.

Start Buildings from Grade.—Let us think of the enormous waste going on everywhere incidental to digging down for cellars and digging, refilling, and redigging and resurfacing of streets, roads and sidewalks, for water and drainage pipes, conduits, sewers and public utilities.

The necessity and opportunity for elimination of waste in this direction is great. I offer for consideration the suggestion, which is not new, that all newly developed areas, and all changes wherever possible in existing cities, shall have buildings started from grade, without excavations except for cuts to use as fills.

Indeed, with modern methods of heating, why should not the average house be built without a cellar, and storage for coal, provisions, etc., be afforded on the ground floor, eliminating waste of effort in going up and down cellar stairs continually.

Why should not streets in cities be built above the ground instead of cutting out the ground under them for every conceivable purpose and over and over again without regard for incidental losses and waste?

Having disposed of the ground (at enormous expense) we now come to construction of buildings. In this whole field, we of the construction industry are too apt to concentrate our thoughts on new work.

This is not right. We must differentiate between repairs and maintenance of existing structures, alterations and additions, demolition and reconstruction, and set it off against new work.

Fire Losses.—Taking up existing structures first—two enormous wastes stand out.

These are preventable losses of property by fire, to say nothing of the more important loss of human life and man power, and preventable losses due to decay and deterioration.

We, through our new American Construction Council, have an unprecedented opportunity to show our enlightened unselfish interest in the public welfare by taking every measure possible to stop a waste of $400,000,000 annually and of thousands of lives and untold millions of man-hours due to fire alone.

The surest means I know of is to make every one careful, and I suggest that we urge the adoption everywhere of personal liability laws to hold individuals responsible for the cost of extinguishing fires due to their neglect or carelessness.

Let us also see to it that all possible fire precaution and protective measures are adopted in new construction work.

The other great waste which I have mentioned in connection with existing structures is the decay and deterioration which, through lack of knowledge and foresight and through downright carelessness, is allowed to go on everywhere when simple preventive measures involving construction materials and labor promptly and properly applied, would save countless millions of waste.

Here we have an opportunity to display our enlightened selfishness by selling the paint-up and fix-up idea to the public in its own interest as well as in the interest of the construction industry.

Saving Through Standardization.—A vast amount of waste due to unnecessary individual effort could be eliminated if architects and engineers would in co-operation with all the industries, standardize the parts of certain buildings and standardize the detail drawings necessary to accomplish satisfactory results.

The participation of producers and manufacturers is vital in this program. Already the Department of Commerce has made a fine start in simplified practice, elimination of unnecessary types, sizes, patterns and finishes of many parts and articles related to construction. Its Building Code Committee is also doing notable work in offering to the country a document which will assist in the economical and safe use of materials and produce further economies in the uniformity of dimensional requirements. The field of standardization is too large to more than touch upon here and of all the many possibilities I will mention only one.

Let us assume that, instead of each architect laboriously making detail drawings for window frames for all normal requirements, a universal box frame and sash were developed and adopted as standard and that this box was carefully and economically worked out to prevent air leakage. What would be the result? Cold would be kept out and heat kept in. Suppose the resultant saving in fuel, aside from the added comfort, was but one-half ton of coal to each home. What would be the elimination of waste on this one item alone?

I leave it to you to figure out, but it would not only amount to millions of tons and dollars, but reflect itself in relief to transportation and all down the line of construction activities.

Wasteful Method of Estimating.—The builder or general contractor next appears upon the scene and, by the use of three simple words in an innocent looking combination, he has had a very large part in causing waste. I refer to the slogan, "Estimates Cheerfully Furnished," which has so greatly contributed to the prevalent wasteful method of estimating on the drawings of architects and engineers. Specifications, too, must be standardized to intelligently say what they mean.

Some means should be devised to eliminate the enormous amount of time expended by builders and subcontractors estimating on every building operation, many of which, as you know, do not proceed. That is an absolute loss. In my opinion builders should be paid a fee for estimating. That would be a benefit in several ways, one of which would be that owners would not require so many builders to estimate, and the builders would not require so many subcontractors to estimate. Overhead would thus be cut down all along the line. The more experienced and capable builders would be given the preference. At the present time, when each builder or subcontractor estimates, each one separately takes off the quantity. Another way to eliminate waste would be to have one quantity statement or survey, so all the contractors estimating would be figured upon the same quantity, and would merely appraise their units and their incidental expenses and attach their proper profits.

Saving Through Co-operation of All Concerned in Construction.—We come next to the actual construction after having awarded a contract for a building, and there we find the greatest opportunity to eliminate waste. The only satisfactory method of proceeding in that direction is to have that complete co-operation between architects, builders, material men, all the subcontractors and all the workers on the job, which will come about through local effort co-ordinated with this American Construction Council.

I want to read a very brief extract from an article in a recent issue of "Forbes," entitled "Industry Can Double Productivity."

"Industrial efficiency in this country is no greater than 40 per cent, and probably as low as 15 per cent of what it should be. A conservative estimate places it at 25 per cent of fair and attainable standards. This means an industrial waste of 75 per cent. If we could eliminate preventable wastes, productivity would increase 300 per cent."

We have been making studies in Philadelphia of this whole question of the elimination of waste, but so far the task has been conducted by the workers themselves, strange as it may seem, and those workers are seeking the co-operation of the architects, engineers and builders, which is very gradually being secured.

Wastes in the Building Trades.—Sanford E. Thompson has said, "Certain wastes stand out clearly in the building trades:

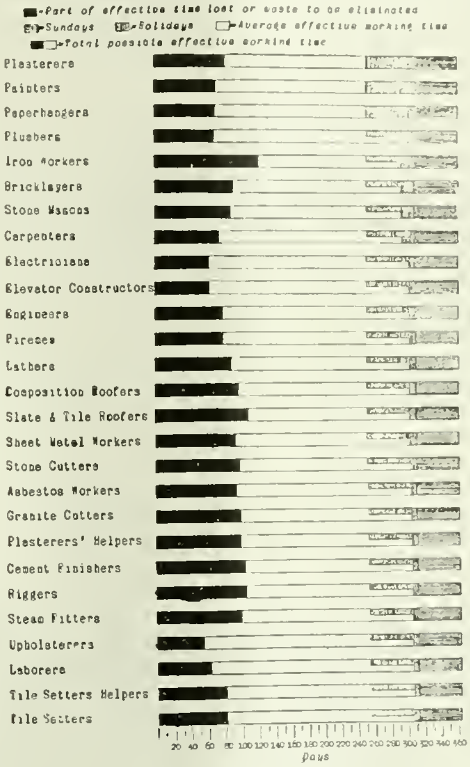
"1. Loss of working time throughout the year.

"2. Poor planning of construction work and of the individual jobs by the builder.

"3. Lack of knowledge of a day's work.

"We find that we must dovetail all these things together, so that every man shall have the opportunity to work; we must develop the technique of each industry, so that every man can make the best use of his powers; we must train the employer to plan his work and also to appreciate the human side of life.

"You may ask why studies of detail, why the determination of standards will aid in the elimination of waste. It is because it will increase the initiative of the worker, it is because it will differentiate the good man from the poor man, it is because it will present an aim to work to, because—and this is perhaps the most important feature of all—it will show us the easiest and most economical way of doing the work and will compel employers to take more thought to the methods of handling the work and to planning out the work that is to be done. Thus costs can be and will be reduced."



Comparison Between Effective Working Days Per Year and All Other Days in Year.

A Central Bureau for Clearing Construction Problems.—I want to add a brief sketch of what seems to me are the most pertinent and important problems to be solved in co-ordination of all facts connected with building. These can all be studied by each local group.

Such a group would act as a central bureau through which, voluntarily, all construction programs could be cleared, including national, State, municipal and private work in each territory. Suggestions could be made for co-ordination of activities, allocation of materials and reduction of estimating costs; local production could be encouraged, rail hauls shortened, traffic congestion lessened; a constant labor survey could be maintained and employment bureaus established to the advantage of the employer as well as of the employee; good management could be promoted, efficiency encouraged, apprentices educated and properly trained; and increased production would result all around.

In such a program another vital necessity is to educate the public to an understanding of the fundamental principles of a sensible distribution of demand for services throughout the year. Instead of carrying on our main construction work in seven or eight months that which could be deferred and done through the remaining four or five months should be so scheduled. Owners making interior alterations or additions to buildings should be encouraged to have this work done in the "off-peak" season. Old buildings should be demolished in the cold weather to make way for the new construction, and not (as is often the case) at the time when the new building itself might be under way.

What the Philadelphia Building Trades Are Doing.—I want to conclude my remarks by telling you of some of the satisfactory work which is being undertaken in Philadelphia by the building trades. It pertains to the elimination of the greatest waste in the building industry, and that is unemployment. When it developed some time ago that no statistice were available or loss of man-hours in the building trades, Philadelphia set out to unearth all information possible. Through the secretary of all the unions and committees in the Council, after months of investigation and final analysis with W. S. Hays, the figures arrived at by us have been charted. I think you will be surprised to find just what actually develops when for the first time, so far as I know, such an investigation has been put under way. This chart is, of course, somewhat tentative; it may be slightly inaccurate; but it represents the best results obtainable at present of investigations by men actually engaged in the building trades. We show you this chart, therefore, for the purpose of indicating the first step in determining the enormous waste that takes place. There are listed 27 of the building trades, the black representing the time in each year in each trade when no work is done. This chart is unique and I hope it will lead to remarkable results by indicating the desirability of similar studies being undertaken in all parts of the country to co-ordinate and develop the building industry. This and all such charts should be corroborated through concerted action with employers, and from now on a part of each union's duties should be to keep time records of all its men and give causes of unemployment for the use of each locality group.

Each trade must be carefully analyzed to find out where the loss exists and how to eliminate it. This is where the real work in co-ordinating building construction to eliminate waste begins. New work should be so co-ordinated with alterations and repairs by spreading them throughout the entire year as to keep up a steady demand for workers. For instance, when a branch of the American Construction Council is set up in Philadelphia, it is to be hoped that building owners and managers, such as those operating national and municipal buildings, industrial establishments, railroad stations and the like throughout the city, will schedule their requirements. The Director of Public Works and other officials, we hope, will immediately co-operate, will ascertain just what private work and other construction is proposed or scheduled, and will endeavor to plan the city requirements so that the peak seasons will not be crowded and overtime arise.

Studies of Separate Trades in Philadelphia.—Studies have been started in most of the Philadelphia trades and are now systematically under way to show what periods of the year are most crowded and hence liable to overtime demands and what periods are slack and in which more employment might be secured.

Suppose a survey were to be made of the structural requirements of the City of Philadelphia. The owners of department stores, of office buildings and of public buildings should endeavor to find out the loss of time during the off peaks in each of the trades, and arrange, if possible, to have the greater portion of their work done in those months when the men would otherwise be idle. The householders of the city could be instructed as to the desirability of having their paperhanging done in January, February or December, for instance, and might be encouraged to so order it. They doubtless would do so as a matter of public benefaction. If the trades were thus employed during the full year, it would not only eliminate waste but reduce costs. I dislike very much to talk about wages; but, if the men could be fully occupied throughout the year, their hourly wages could be reduced, and their annual earnings increased to the benefit of American standards of living. The cost of building would fall in each branch of the trade throughout the entire structure, and throughout the entire year, in this locality and in all localities.

International Engineering Congress in Brazil.—An International Engineering Congress will be held in Rio de Janeiro from Sept. 7-30. The Congress will be under the auspices of the Brazilian Government and will be held in connection with the Brazilian Exposition which opens Sept. 7 and ends in March, 1823. The Engineering Club of Rio de Janeiro is in charge of the Engineering Congress.

Present Situation in the Building Trades in New England

In the Boston Transcript of June 17, Mr. Morton C. Tuttle, General Manager Aberthaw Construction Co., Boston, Mass., gives some interesting information on the building situation in New England. We quote his article as follows:

It will be interesting to observe the next three months' development in the building trade because the increasing buying by the building trade will stimulate not only the production of building material like steel, lumber, cement, but also will have a tremendous effect upon railroad traffic. It is also worth while to watch developments in the building labor field, because the reactions in the building trade occur with almost laboratory quickness. Movements in the building market probably forecast very accurately the slower but similar movements in manufacturing, giving as accurate a forecast of the future of industrial conditions as can be obtained. If rising costs halt buying of buildings, similar results may be expected in the market of manufactured material. For these reasons it may be interesting to consider the present situation in the New England building trade.

Post-Bellum Prices.—Following the war there was a building boom, largely caused by the expansion of factories. This boom raised the cost of building until in the middle of 1920 it cost $266,000 to build a factory that would have cost $100,000 in 1915. Following 1920 came the depression, and the price of buildings dropped to 150, compared to the pre-war 100.

The falling cost of building met the rising rents late in 1920, and since that date a greater return can be obtained from rents from a new building than could be obtained in 1915. An accumulated shortage, plus the stimulation of greater rent return, has brought on a tremendous volume of home building. This home building activity is nation-wide. It is unusual to ride ten miles near any populous centre of New England without passing several houses in process of construction. The dropping costs of office buildings met the rising rents precisely as in the case of the dwelling houses, and only a lesser activity has resulted in this line of work. Into this active market has also come the demand for hospitals, schools and public buildings of all sorts, and a belated programme of road building and public improvements. Building of factories during the last two years has been in very small volume. Manufacturers have been concerned with cutting down inventories, reducing expenses and searching for increased markets, and have hesitated to put money into capital expenditures.

The mechanics that follow the city building trades seldom go outside the cities on industrial work. They work close to where they live, and during the depression in city building, these men have been frequently out of employment. Wage cuts have been accepted, and during this time of dearth of employment union men worked with at least superficial cheerfulness beside non-union men. During a depression of this sort few apprentices have been trained. The aggressiveness of the labor unions has been softened, and the employers have had a buyer's market, so far as labor is concerned. During this period the union men have assured the employers that later on when business becomes more active, there would have to be a realignment and readjustment. It seems probable that belated questions of unionism, working rules and rates will be taken from the table during the coming summer. In the face of these known conditions anyone outside the building trade would promptly suggest that the design of buildings should be changed to accommodate the shortage in certain trades. This is far easier to suggest than it is to carry out.

Building Costs.—The principal elements in an office building, a hospital and school are as conventional as the trimmings of a dinner coat, and accordingly when office buildings are wanted, the demand fails on the already overloaded trades. The buyer of factories has a far wider choice of material and design than has the buyer of an office building, or even of a private dwelling house. The cost of factory construction will probably advance less rapidly than the cost of architectural work. For years before the war, building costs were on a fairly level basis. The costs of brick work and of carpentry were so stable that they became almost traditional and the estimating of work was a simple process. The varying costs of the last five years, however, have made all the old data useless, have made it exceedingly difficult to estimate the cost of building. Even if the cost of a building can be estimated as of given data, it is difficult on a fluctuating market to project this estimate over a period of eight to twelve months. During the period of rising prices this difficulty manifested itself in the frequency with which estimates were overrun.

Following the peak we have a sharply dropping market in which it has been easy to estimate work, because the market has been constantly dropping and estimates were underrun. About the first of this year the cost of buildings reached bottom remaining horizontal for February and March, and then began to rise until today it is safe to say that the cost of buildings has risen eight to ten per cent since the first of the year. This rise occurs in several ways—in the stiffening of prices of materials—steel, brick and cement have all risen. Lumber has not only risen in price, but the time for delivery has increased so that a shipment which was made within a week after receipt of orders requires three months for shipment, unless bonus is paid for prompt shipment. Wages are stiffening.

During the depression of last winter, there was less unemployment than was commonly anticipated during the fall. Activity in many manufacturing lines has visibly increased, and this activity has absorbed some common labor. The greatly increased activity in the building trade has absorbed still more, and this has resulted in a shortage of the better grades of unskilled labor. Limited immigration and considerable movement toward their native country of former immigrants has shortened the number of men available. Our immigration laws prevent influx of labor supplying any bulge in labor requirements.

The Question of Labor.—It is increasingly difficult to get men to move to distant places or to take on the less attractive forms of common labor without price concessions. New England has learned to rely largely on Italian labor. Today it is very hard to get together a large body of first-class Italian laborers, and New England has no other laborers the equivalent of first-class Italians. The substitution of less competent labor at the same rate paid to better labor produces higher labor costs, and this process of raising labor costs on a horizontal wage scale is now under way. It is reasonable to expect this to be followed sooner or later by bidding up for the best labor. As labor becomes scarce and poorer men are substituted for better, the better men slow down to the accomplishment of the poorer ones. When bidding for labor becomes brisk, there is a further slacking down, because with the knowledge that jobs are readily available, workmen become independent and careless. In building operations these two processes of dilution of good labor gangs, plus the feeling of independence arising when bidding for labor sets in, results, without wage change, in at least a 20 per cent increase in labor cost. It is possible that this summer the Boston building trade will experience the effect of dilution plus bidding. To the manufacturer who will face the same problems it will be interesting to see how the matter works out. Most city building is let on lump sum bids. The bidder is selling futures, because his operations will continue over a period of eight to twelve months, and he has based his estimate on a theoretical wage scale and labor output for this period of time.

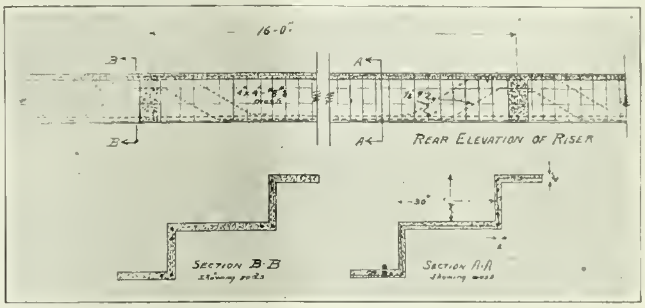
Thus it is reasonable to expect a prompt stiffening of the wages of common labor. Certain of the building trades are undermanned, the most conspicuous case being that of the plasterers. England is as short of plasterers as the United States, and it is quite improbable that there are enough of these men available to do the work that is prospective. The plasterers' wages have already climbed and the bidding for their services is active. Only second to the plasterers come the brick masons, who, like the plasterers, are selling their services to increasingly active bidding.

The Basis of Bidding.—So much work is already under contract that we are likely to see the full working of the law of supply and demand carried pretty well to a conclusion in the New England building trade labor market. It is fairly easy to forecast that as soon as the situation is clearly recognized in the building trade that the basis of bidding will rise sharply. Many contracts have been taken on the theory that wages were to remain stable, and last spring some were even theorizing about lower wages. It is easy to anticipate that there may be a scramble to recoup losses by trying for higher prices on future work. Meanwhile many bidders will be uncomfortably trying to work through operations which aggregate millions taken on a very low price basis.

The best opinion seems to be that the bottom of the building market has been passed. If on a rising market large volumes of building work continue, then manufacturers may reason that the public is ready in turn to buy of their merchandise when their prices rise. If, on the other hand, the volume of contracts let sharply declines as prices rise, this will be of significance to the manufacturer and the merchant. In any case it will be interesting and profitable to follow the building market for the next few months.

Test of a Gunite Stadium Seat

Tests were made recently at the Concrete Products Shop at Harvey, Ill., of the Cement Gun Construction Co., Chicago, of a 2-in. thick stadium seat made by the cement gun process. The diagram shows the detailed design of the 16-ft. section which was made in February, 1922, by the Cement Gun Construction Co. The first load applied was 150 lb. per square foot. A week later the load was increased to 250 lb. The load was then brought up to 291 lb. per square foot by piling bricks on top. Next, four men climbed on top to see if by teetering they could make the section break. The attempt to break the section was given up. The final load with the four men on top was 301 lb. per square foot. Under this load the deflection at the center was a little over 1 in. A number of fine cracks developed. When the entire load was taken off the deflection came back to ¾ in. There was no evidence anywhere of any crushing of the gunite.



Details of 16 Ft. Section Gunite Stadium Seat.

The Final Load, 301 Lb. Per Square Foot.

Building Trades School Started by Landis Award Committee.—The Citizens' Committee to Enforce the Landis Award in Chicago has started a building trades school, with a class in plumbing as the first of those intended to end the shortage of mechanics in the thirteen "outlaw" trades. The pupils who formed this class were for the most part employed during the day on Landis Award jobs, and who saw the opportunity to gain the training necessary to become foremen or superintendents. A number of others, however, were novices who took the chance to learn a paying trade.

Cutting Costs with the "Progress Chart"

How a Large Construction Company Insures Orderly Building Operation Described in The Constructor

By H. N. Snow,

In Charge of Construction, Hoggson Brothers, New York and Chicago.

The progress chart has its place in the work of large building concerns and has resulted in such obvious benefits where used, that its adoption can be strongly advocated for even the smallest operations. Early in Hoggson Brothers' career the need was felt for some orderly visible method of keeping in touch with the progress of a number of operations all going forward simultaneously. Various forms of charts were experimented with, until the form now in use in our construction department was adopted as the one most satisfactory from every standpoint. This progress chart is now used for every one of the company's building projects, from the smallest alterations to the largest bank and office buildings.

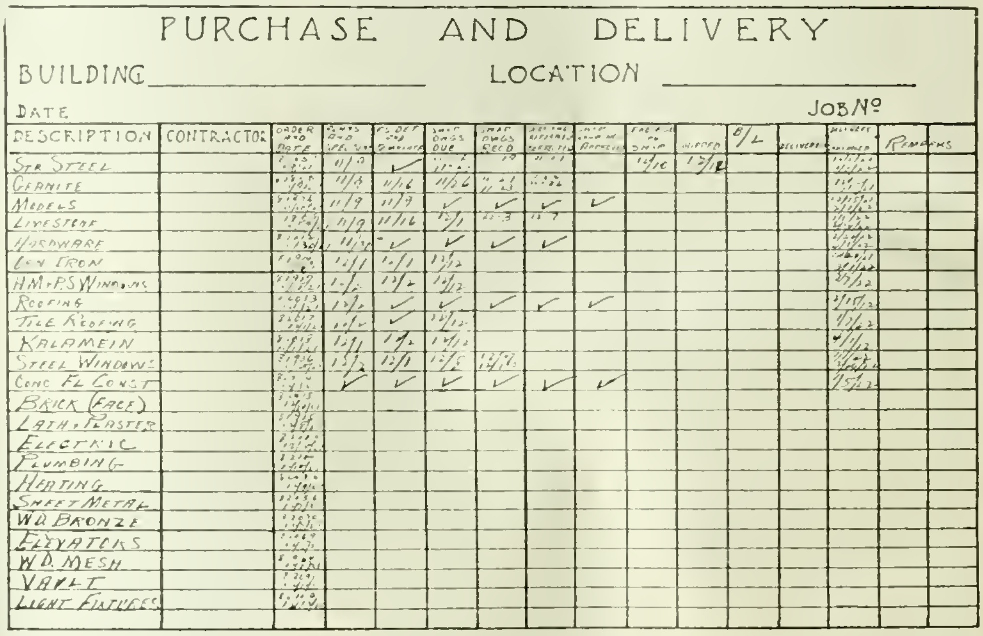

PURCHASE AND DELIVERY
BUILDING
LOCATION
DATE
JOB Nº
DESCRIPTION
CONTRACTOR
B/L
REMARKS
STR STEEL
GRANITE
MODELS
LIMESTONE
HARDWARE
ORN IRON
H.M. & P.S. WINDOWS
ROOFING
TILE ROOFING
KALAMEIN
STEEL WINDOWS
CONC FL CONST
BRICK (FACE)
LATH & PLASTER
ELECTRIC
PLUMBING
HEATING
SHEET METAL
WD BRONZE
ELEVATORS
WD. MESH
VAULT
LIGHT FIXTURES

Fig. 2.—Purchase and Delivery Chart.

Functions of the Chart.—With a progress chart an entire building operation becomes an orderly progression of events, each step anticipated, fully prepared for and falling smoothly into its place after the preceding step; the builder being able to estimate accurately the completion date of the job and the owner receiving his building on time.

But, most important of all, the greatest advantage of the progress chart is to be found in its money-saving feature. Such a method of controlling a building operation results in a very material saving on the total cost of an operation. To get a clear conception of the way cost can be reduced by means of the chart, it is necessary to state briefly its use.

At the start of each operation, it is scheduled on a chart (Fig. 1), which gives specific dates for the completion of all the steps comprising the job. Such a schedule must, of course, be prepared by one who is widely experienced and familiar with general conditions, as well as the features peculiar to each project. The typical progress chart includes such items as "temporary quarters," "demolition," "structural steel," "masonry," "cut stone," "carpentry," "hardware," "plumbing," "heating," "electrical installation," "floor coverings," "lighting fixtures," etc., clear through to the "final clean-up."

Material Delivery Dates Included.—In addition to the specific dates for the completion of the various stages mentioned, the progress chart carries delivery dates for all manufactured articles which are to go into the completed building. This is the secret of both the cost-reducing function of the chart and also of its success as a "time table"; for, in order to keep to the building schedule, it is necessary to insure the compliance of the manufacturers with their delivery dates. A very integral part of the schedule is the "subschedule" of secondary processes. Therefore, there is scheduled, prior to each delivery date at the site, the required time for the various steps in the manufacture of the finished products. The orders are then placed in plenty of time, the manufacturers followed up at each step and their progress checked against the requirements for delivery on time.

Purchase and Delivery Chart.—The scheduling of the time required for the manufacture of the various finished products appears on the chart only as the distance between the "buy" and "delivery" dates. The actual record of these processes is kept separately on a secondary chart called the "Purchase and Delivery Chart" (Fig. 2). On this chart are entered the dates for ten steps which carry each sub-order through to delivery at the site. These dates are:

Order date; plans and specifications to manufacturer; full size details and template measurement to manufacturer; shop drawings due in home office; shop drawings returned for corrections; shop drawings approved; manufacturers' promise of delivery; final date of shipment; bill of lading received; superintendent's report of delivery.

Further details, such as the record of the various items of an order for bronze work, for instance, are kept in the form of a tickler card. This arrangement accomplishes two things: first, it keeps the progress chart down to a minimum of entries and, by simplifying the entries of progress, results in its being kept up and used; second, it allows for a much more detailed description of the minutiae of each subschedule than would be possible, were this information all to go on the central chart. A further advantage is the possibility thus afforded of dividing up the purchasing on all current operations between a number of executives, each of whom is responsible only for the buying for the jobs with which he is entrusted. The follow up of manufacturers and the entries on the "Purchase and Delivery Charts" are in charge of an expediting executive, who has this function only. This man receives carbons of all orders to subcontractors, which serve as his cues for the first entries on his charts, after which he takes the initiative and acts as a liaison officer between the purchasing department and the other departments of the organization as well as with the subcontractors.

Checking Done by Home Office.—In the case of our own concern, where each job is under the supervision of one of our superintendents, the checking up of manufacturers is done by the home office, while the superintendents' regular reports indicate the amount of material received at the site at each date of writing and summarize each week the progress in each division of an operation. These reports are then checked against the job schedule in the home office.

This method, which has been developed for the insurance of prompt deliveries of materials, shortens the time required for the construction of a building, results in a consequent saving in the total cost of the owner, and gives him his building for use or for income-producing purposes at an earlier date than would be possible without some such form of scheduling and controlling the progress of construction.

Compression Tests of Forging Steel at High Temperatures.—A series of compression tests at temperatures between 20° and 700° C. on carbon forging steels has been completed by the U. S. Bureau of Standards. In this series the proportional limit decreased slightly with rise in temperature to 300° C. and thereafter more rapidly to a very low value at 700° C.

Structural Steel Inspection

During last year the inspection staff of the laboratories department of the Hydro-Electric Power Commission of Ontario inspected upwards of 11,000 tons of structural steel used by the construction department for buildings, bridges, transmission towers, penstocks and tanks. How this steel is inspected is described in a recent bulletin of the Commission.

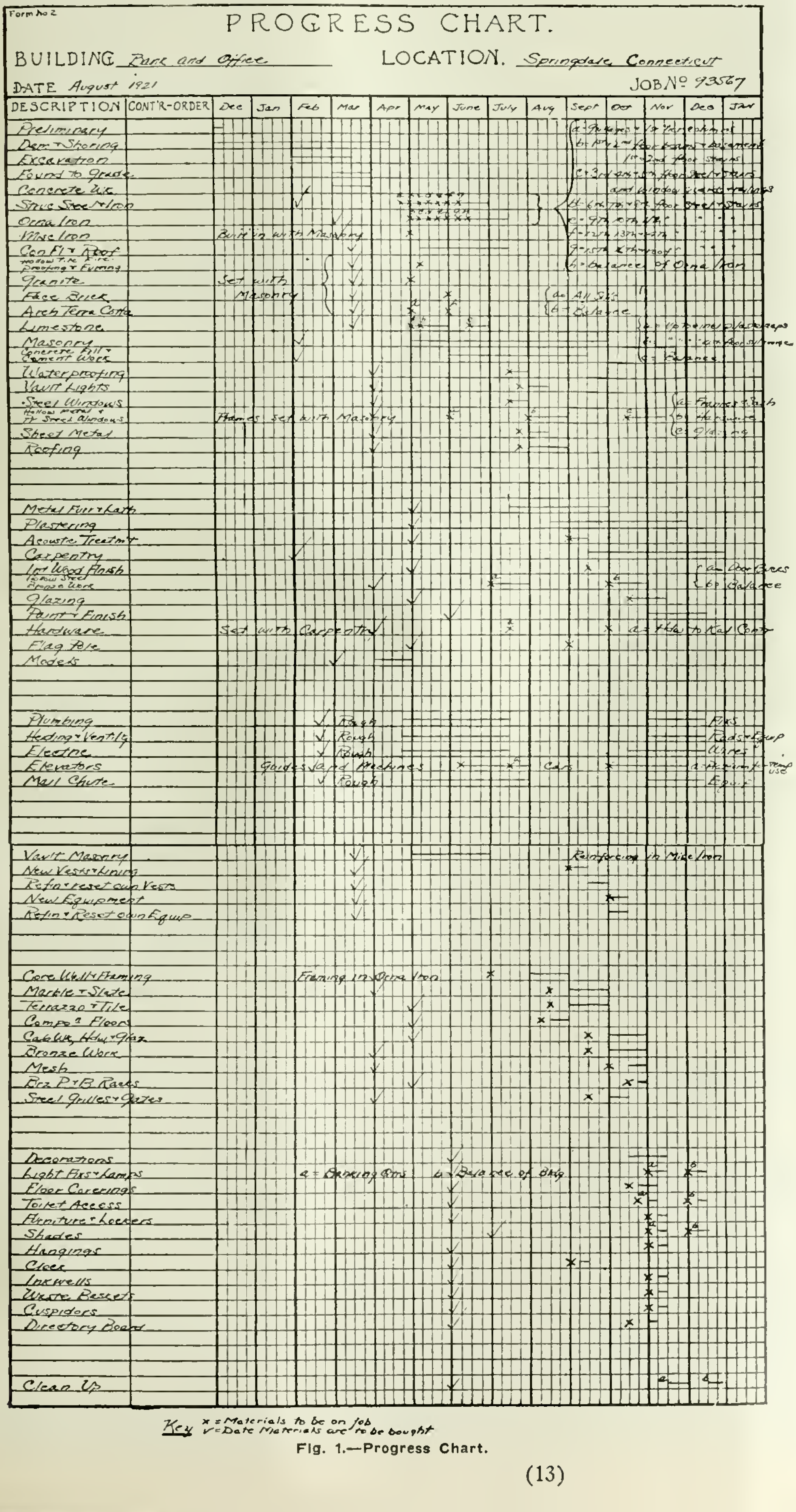


Fig. 1.—Progress Chart.

Inspection as ordinarily provided for in specifications is a form of insurance. Its object is to insure the performance of the specifications in all details so that the purchaser will receive that which the manufacturer contracted to deliver.

The inspection of structural steel with which this article is specially concerned may be classified into the inspection of—

(a) Materials;
(b) Workmanship.
(c) Dimensions;
(d) Erection.

Inspection of Materials.—Inspection of materials covers all the processes of manufacture as well as inspection of the finished product. In all but exceptional cases it is sufficient in the inspection of steel for structural purposes to confine the inspection of the material to an examination of the finished product. This includes testing samples of the steel to determine if the chemical and physical properties are correct. In the surface examination of the steel defects such as slivers, cracks and blisters are noted and where they are of a serious nature, they are cause for the rejection of the pieces in which they occur.

Rusted surfaces are also examined and the inspector has to distinguish between surface rust, which can be removed with a wire brush, and pitting which is more serious, and which is usually a cause for discarding the material.

Inspection of Workmanship.—Under this heading come the various operations carried out in the shop, the most important of which are shearing, punching, reaming, fitting and riveting. It is the duty of the inspector to see that these are properly carried out without damage to the steel and in accordance with the specifications.

There are some points about which the inspector has to be particularly alert. In shearing care should be taken to see that the distance from the centre of rivet holes to the edge of the plate is not less than the minimum distance required by the specifications. In punching, the centering of rivet holes should be taken to see that the drills are inserted at right angles to the axis of the member being drilled. In fitting all burrs should be removed from the edge of rivet holes and the pieces drawn together and bolted tightly with sufficient bolts to keep them in close contact while they are being rivetted.

Careful attention should be given to the matching of the holes when two or more pieces are to be rivetted together. If the matching of the holes is not good, it may be corrected,

Estimating Labor Costs on Building Construction

Introductory Chapter to the "Building Labor Calculator"

By GORDON M. TAMBLYN,

General Contractor and Public Estimator, Denver, Colo.

In preparing what I have termed Constants of Labor I am not unmindful of the many elements that enter into construction that will make the actual cost of work vary from the most carefully prepared estimates. For the last fourteen years I have devoted fully two-thirds of my time to compiling estimates for contractors on jobs that range from thousands to millions, and without any desire to advertise matters on which modesty would suggest silence, but merely to establish confidence in those who may be strangers to me, I will add that during the fiscal year just ended I have completed my own contracts, amounting to a quarter of a million dollars, on which only about 3 per cent was sublet. The work above mentioned was estimated on the basis of the constants included in this binder, and while some variations occurred in the actual costs as compared with the estimates, yet as a whole the variations were less than 2 per cent. Therefore, I confidently recommend these constants of labor as reliable and under average conditions and organization the contractor who uses them will appreciate their value.

My object in writing a brief preamble to the system of figuring contained herein, in the form of a pamphlet, is to convey my message to the prospective user of the work, establish confidence, suggest rules of measurement on which the constants are based, and by thus doing, leave the actual figures a clear, open page untrammeled by a lot of useless information that only tends to confuse rather than enlighten.

Once the system is understood it will be unnecessary to review what I have to say in this preamble. You, who use this book, will be its judge, and I send it forth with confidence that it will tend to better methods of estimating builders' work, and invite your constructive criticism.

The book is loose-leafed—I trust it will never become hidebound. I am devoting my entire time now to preparing such tables as are contained herein, and tables for short cuts in listing materials, for the students of the Western School of Estimating, Denver, Colo. I may add that all of the students in this school are practical men, having worked at some one of the building trades, and approximately 50 per cent of them are contractors, representing practically every State in the Union and a number in Canada.

The users of this book will be entitled to the tables referred to above, and by signing the enclosed card and returning to my office you will be placed on the mailing list and will receive the tables punched for the binder without any additional charge for the first year.

Before going into detail on methods of listing, a few general remarks may not be out of place.

Builder's work consists of two main items: quantities of material and quantities of labor. Materials of differing grades and prices subject to changes in different localities. Labor of different classes, skilled and unskilled, varying in grade and price also.

Material may be said to be a fixed quantity measured from the plans and its quality fixed by the specifications.

Labor is a variable quantity; its unit is the hour. The quantity varies greatly, due to numerous reasons well known to contractors.

Labor requires much more skilled supervision today than twenty years ago. Now, men pick up their trades to a great extent. Then it was obtained under contract. The constants given in the following pages may serve for a year or two, but unless something is done to train new recruits to fill the declining ranks of skilled laborers, output will continue to decline and the constants will require revising.

In spite of the variableness of labor's output there is a law of averages which, if carefully tabulated, has the best guess in the world beat. In the same manner insurance companies base their premiums on averages, taking into consideration losses in areas where epidemics reign and probable profits where the mortality is low, over a period of years. So labor's output can be averaged and conservative estimates are made which though subject to variations come out with the total estimate with surprising accuracy.

Since labor estimates are based on the amount of material to be handled, it is very important that correct methods of listing be employed. It makes no difference how close the labor constants may be computed, unless the material bill is correctly entered into the estimates, a difference will show up in the payroll as compared with the estimate. For this reason I will outline what I believe to be correct methods of listing, and will give a few points that I have found to be helpful in striving for accuracy.

Probably more mistakes are made in listing materials than in any other operation connected with making an estimate, and the reason mistakes are thus made is due oftentimes more to lack of system than to lack of knowledge.

It is not my object to go into minute detail as to what should be listed, but to suggest a few particular points I have found to be of great help in making estimates. All of these points tend to lessen the danger of overlooking or duplicating items.

We have often heard it said of the contractor who is "low bidder" that his first thought is: "What did I leave out?" He notes that other bids on the same work are a good deal higher than his; he knows he priced the job carefully, and his extensions and footings were checked, and naturally he thinks the only mistake he could have made is to have omitted something in listing.

Sometimes a general contractor will find after he has been awarded a contract that one of the sub-contractors, whose figures he has used, has made a mistake and wants to be relieved of responsibility by withdrawing his figure. This puts the general contractor up against a probable loss if he has signed up for the job. I have known instances where general contractors have withdrawn their bid, or refused to sign up a contract, giving as a reason that one of the sub-contractors, whose figure he had used, had made a mistake. This is purely "passing the buck." Any contractor who puts in a bid based on sub-bids that he has not checked can be judged as incompetent or guilty of gross neglect.

Various reasons are given by contractors for making bids too low, few of which are valid. I will give two that are common:

1. **Incomplete plans and indefinite specifications.**
2. **Lack of information regarding local conditions.**

No contractor, who knows his business, would submit a close bid on an incomplete plan, or one that did not fully represent the work that it is evident should be done, neither would he put a close price on material that was not clearly specified, unless he wanted to take a gamblers' chance.

The fact that a contractor submits a bid to do a certain job according to plans and specifications, should be taken as evidence that he fully understood each point, and he should carry out the evident intent of the plans and specifications without quibbling over small matters after the work is well on way.

If the plans are incomplete, or the specifications indefinite, it is certain the contractor is left in doubt, but there is no excuse for setting a price on an unknown quantity or quality. The contractor should go to the architect and settle all questions definitely, and have a clear understanding before submitting his bid, and then see to it that the contract is written on the same basis as the bid was submitted.

What I have to say in regard to system in estimating has reference to complete general estimates in particular. I do not think the average sub-contractor who only figures one branch of the work, can possibly understand the plans, or make as accurate a quantity list as the general contractor who figures each branch of the work.

I am showing on page 11 a form of estimate, and I will endeavor to explain its use and give a few pointers on listing:

At the top is a space for "sheet number" and the "total number" of sheets. It is important that all sheets be numbered, and when the estimate is complete the total number of sheets should be inserted after the "of." If there are 16 sheets in the complete estimate, the sheets should read "Sheet No. 1 of 16; "Sheet No. 2 of 16," and so forth. Where sheets are not carefully numbered there is danger of losing one or more, which might seriously affect the bid and cause a loss.

Before you can do any listing it will be necessary to study the plans to get a correct idea of the job as a whole, and the following items should first be entered on your estimate as a description of the building. You will find these dimensions will be valuable in many ways. For convenience of description let us take a two-story school building as an example.

Length of building 150 ft.; width of building, 50 ft.; two-story and basement. Give the following description:

Perimeter	400 ft.
Area building covers	7,500 sq. ft.
Basement cement floors	7,000 sq. ft.
First and second floors, 2x10—16-in. o. c., area	11,400 sq. ft.
Roof measuring to outside of walls	7,500 sq. ft.

Basement walls, 16-in. concrete to grade.
First and second story walls, 13-in., brick.

Any items that will more clearly define the nature of the work should be noted. Writing them down assists greatly in memorizing.

To acquire speed in listing a job it is imperative that memory be cultivated. Practice will make it possible to memorize a specification with about one reading.

Having written a rough description of the building you now take the specifications, and beginning at the first branch of work you read this branch alone and make general notes of main points in the memorandum margin of your estimate sheet. These notes will probably read approximately as follows:

EXCAVATION.

Natural grade, 1′ 4″ below finish grade.
Surplus dirt to be carted distance of one-half mile.
Ordinary dirt excavation to 3′ below finish grade.
Usable sand 3′ to 6′ below finish grade.
Gravel from 6′ below grade to lowest point of excavation.
Excavation to be 1′ 6″ clear of outside walls.
Water struck at 8′ below grade.

In order to make an intelligent estimate on the excavation such general points as the above must necessarily be fixed in the estimator's mind before listing can be commenced. Writing them in the memorandum space serves the twofold purpose of impressing them on the mind and having them on hand for ready reference.

The order of listing should be the same as the order following in actually doing the work.

First list the main excavation, which should extend to approximately 18 in. clear of the walls all around and to a depth equal to the depth of the bottom of cement floor in basement.

Assuming the bottom of basement floor is 9 ft. below the finish grade, your entry under main excavation would read about as follows:

MAIN EXCAVATION.

Ordinary dirt	53′ 0″ x 153′ 0″ x 1′ 8″
Sand	53′ 0″ x 153′ 0″ x 3′ 0″
Dry gravel	53′ 0″ x 153′ 0″ x 2′ 0″
Wet gravel	53′ 0″ x 153′ 0″ x 1′ 0″

Segregating as above provides for intelligent pricing and credits for sand and gravel that can be used in the building. It also makes provision for special consideration of water conditions.

Excavation being one of the most uncertain operations connected with contracting, architects, on work of any importance should, at the expense of the owner, have sufficient test holes dug, readings taken, and made a part of the specification for the contractor's information. The points at which test holes are made should also be designated on a plot plan together with the natural grades. Such information is necessary to make an intelligent bid, and whether the architect gives the information or not, no bid should be submitted by the contractor until he has secured the same, or is reasonably sure of the ground from experience on other work adjoining the site.

The next items that should be listed are trenches for wall footings, pier holes, elevator pits, and any other work that goes below the main cellar floor line.

Water should be considered under a separate heading and listed in a manner that provides for intelligent pricing.

Backfilling is usually the last item to be considered. This should be figured and listed separately.

If sheet piling or the shoring of structures adjoining the building site are necessary, these should be treated separately and in detail.

Following the general order of construction, and the lead of the specifications, next comes the concrete footings and walls.

Foundation Walls and Footings.—In this particular case that portion of the foundation walls and footings that come below water line should be listed separately from the portions above water line. If there is any difference in the mix of the concrete, or any points that are difficult of access another separation is necessary and note of same recorded in memorandum or preceding the item.

After listing the concrete, sufficient space should be left blank on the estimate sheet to analyze the component parts of the concrete per cubic yard. For an example, let us take 1:2:4 for the mix specified for the concrete, and 10 per cent hydrated lime added. You list as follows:

MATERIAL.

6 sacks cement, at 80 ct.	$4.80
.45 cu. yd. sand at $1.50	.70
.90 cu. yd. gravel at $2.50	2.25
60 lb. hydrated lime at 80 ct.	.48
Water	.10

LABOR.

(Use Constants of Labor, Page 3.)

.... hr. common labor.
.... hr. engineer and mixer.
.... hr. foreman.

Fuel and depreciation of plant are charged on a rental basis per hour.

In cases where hoisting engineer is required, etc., analysis must be made according to the method to be used to suit the nature of the work.

Material items are extended in the "material" column of the estimate sheet. Labor items are extended in the "labor" column.

Hauling machinery to job, erecting towers and chutes, dismantling and removing same, should be treated as separate items.

Of course in construction forms come before concrete, but on account of the fact that the forms can be figured from the dimensions given in the estimate for concrete, the logical place in the estimate is directly after the concrete.

In many instances forms are not required for footings, but since the footings and walls are listed separately there is no difficulty in segregating.

Some contractors estimate form work at so much per cubic yard of concrete. This is practical only where the walls are of the same thickness. The only correct method is by obtaining the superficial feet of surface to be formed, measuring both sides of the walls. After the superficial feet have been determined it is a simple matter to estimate the amount of lumber, wire, nails and labor, by using tables and constants of labor in hours. (See pages 4 and 4A.)

Brickwork.—The next item in order is the brickwork. After carefully reading the specifications and making notes in the memorandum column, proceed to list the brickwork by floors or stories. Always figure the brickwork "net"—"kiln count." Brick that are to be laid in "cement mortar" should be listed separate from brick specified to be laid in "lime mortar." Face brick that are to be laid in special pattern should be listed apart from face brick laid plain. If walls are exceptionally high above adjacent floor, requiring special scaffolding, wind bracing and additional hodcarriers, this portion should be saparated and description given covering the condition.

Sufficient blank lines should then be reserved on the estimate sheet to analyze the material and labor required to lay a thousand brick of each kind.

Example:

MATERIAL.

1,000 brick at $15 at kiln	$15.00
Hauling to site at $2	2.00
¾ cu. yd. screened sand at $1.50	1.12
2 bu. lime at 80 ct.	1.60
Water	.10
	$19.82

LABOR.

(Use Constants of Labor, Pages 7 and 8.)

.... hrs. bricklayers' time at..........$................
.... hrs. laborers' time at............$................
.... hrs. engineer and hoist.
.... hrs. foreman.

Cost of face brick and other classes of brickwork are analyzed in the same manner.

Rough Carpentry.—Next in order is rough carpentry. After studying the plans and reading the specifications, list this work, beginning at the foundation and keeping each story separate, build up in order as follows:

Basement.—Posts, girders.

First Floor.—Joists, bridging, sub-floor, finish floor, stud partitions, grounds.

Second Floor.—Joists, bridging, sub-floor, deadening felt, finish floor, stud partitions, grounds, ceiling joists.

Roof.—Joists, bridging, sheathing, raggle strips, bracing.

Miscellaneous.—Lintels, furring, nails and bolts.

In the memorandum column of the estimate sheet enter the net floor areas for sub-floor. When the board feet of lumber have been totaled from the items listed, it will be found an excellent check to take the area of the sub-floor and multiply by the "multiples" for various sized joints at given centers according to tables I have prepared for your convenience. Suppose your sub-floor area is 10,000 sq. ft., and the joists are 2x10, spaced 16 ft. o. c. You multiply 10,000 by 1.4 (see tables) which gives you 14,000 ft. B. M. for joists If your itemized figures vary to any extent from this total you may be sure you have made a mistake in listing. This same method may be applied to stud partitions of roof rafters, providing the net area is known and the dimensions of joists, studs or rafters. You will find the table can be applied to almost any condition of framing where dimensions are of equal size and spacing.

When figuring the area of floors, walls, partitions, roofs, etc., to arrive at a quantity of lumber, brick, partition tile, roofing, etc., this net area should always be put down in the memorandum column. It will be found very handy later as a rough check on plastering, painting and various other items. The running feet of partitions of various kinds should also be made note of in the memorandum. This, with the perimeter of the building noted at the front of the estimate, serves as a rough check on plastering, base and other items.

Plastering.—Assuming you have covered all the rough carpentry work, the next operation is the plastering. This branch of work should be listed by floors or stories. Plastering on brick walls, concrete, tile partitions and general masonry work must be kept separate from plastering on lath. Plastering on wood lath must be kept separate from plastering on metal lath. Rough rubble masonry walls should always be listed separate from brick walls, etc., that have a more even surface. Rubble stone walls usually require a heavy coat of plaster to make them plumb and straight, and for this reason should not be mixed with plastering on other masonry in listing.

Segregating the work as outlined above, figure all walls, partitions, ceilings, etc., "solid." Make no deductions for ordinary openings such as doors, windows, etc. Where cement wainscotts, cornices and such items occur include them in the measurements for plain plaster. Later when wainscott and special plastering is listed separately, credit can be given for plain work already listed.

In listing plastering, like brickwork, make mention and keep separate all items that are difficult of access and which require special scaffolding.

When the list has been completed, make a grand total of all the plastering in the job, and for comparison go to the memorandum column and add up the net areas of all floors (which equal ceiling dimensions) and partitions (multiply by 2 for both sides), and take the perimeter of the building times the height of as many stories as are plastered. These items added together make an excellent approximate check on the total plaster yardage.

To list plaster on outside walls, take the perimeter of the building on the inside of walls. List partitions by taking the running feet of partitions times 2 sides, times the height. In checking off the plans measure all partitions running east and west and next all partitions running north and south. Start checking off at a given outside wall and check off all partitions to the opposite wall. After you have swept the plan in this direction take all partitions running in the opposite direction. This method is much safer than taking partitions running in opposite directions at the same time. Ceilings should be measured by multiplying the entire length and width of the building inside the outside walls. If certain rooms or spaces are not to be plastered, such rooms or spaces can be deducted from the total area.

Plaster cornices, moldings, cement base and such items should be listed in lineal feet, giving the girth, and in case of furred cornices, note should be made of the kind of furring and lath, whether wood or metal.

Circular or vaulted ceilings should be separated from plain work. Suspended ceilings should be separated from ceilings lathed on the framing.

All ornamentation on ceilings, walls or cornices must be listed and described separately, and priced as extra over plain work, and where necessary a rough sketch made on the Estimate Sheet to convey the correct idea. The number of models should be made note of as it is usually the big item of expense.

Where plastered window or door jambs are specified with bull nose or corner bead at corners, such corners should be listed in lineal feet.

Sides of "plain plastered beams" should be listed in square yards with additional mention of "arris" in lineal feet.

Corner beads are also listed in lineal feet.

Mill Work.—After plastering is completed we next take up "Mill Work" and "Interior Finish." We can only touch on this branch of the work in this connection, and it is my intention only to emphasize a few important points.

First: List all work in connection with the basement, both outside and inside. Your first items should be windows. Imagine yourself on the outside of the building and commence with the window at the right hand side, front, shown on the basement plan and also shown on the right hand side, at grade, of the front elevation. For your further information, this opening should be described as follows:

2 windows 4 lt. 14 in. x 22 in.—1¾ D. S., pine.

1 twin mull, box fr. 22 in. wall, 8 in. reveal, sq. hd. (Standard.)

1 set sub. jambs, clear Y. P.

1 side trim consisting of casings, sash stops, stool and apron, clear Y. P.

2 sets weights and cords.

2 full wdw screens, 1⅛ in. pine, standard black wire.

Note: 8 in reveal means that the face of the frame sets back 8 in. from the face of the wall and determines the width of sub-jambs and stool.

In listing windows or outside openings of any kind, start at the right hand side of the front elevation, and check off the openings in turn, following the direction in which the sun travels, clear around the building until you reach the point from which you started. As you count off the number of openings of each kind make a check mark on the plan and also a corresponding mark on the elevation. In this way you will be less liable to overlook items. You should never check off openings from the elevations only, for the reason that where courts occur in buildings the openings do not always show up on the elevation. If a window is shown on the plan and for some reason is hidden on the elevation, unless otherwise mentioned or detailed, it is taken for granted the window is of the same height and design as that shown adjoining or similar rooms shown elsewhere. This rule of checking openings both from plan and elevation should never be varied. If you follow this rule it is almost impossible to make a mistake in quantity.

After the windows and casement sash have been listed, the doors should next be taken. You are still on the outside of the building and having taken off all mill work except the doors, imagine yourself checking off the outside doors as you enter the building.

Having listed all the outside mill work for the basement from the outside and the outside doors as you entered, the next thing to do is to check off and list the interior doors, sash and any other openings that are finished with wood, and carefully check off all other items of trim or mill work the plans show or the Specifications call for. After assuring yourself you have listed all the work in the basement, both outside and inside, you now walk upstairs to the "first" or main floor. Going upstairs suggests "stairs" and you proceed to list these as you go up, checking off and describing as fully as possible.

One reason for listing floors separate is that sometimes to hold the job down to available funds the finish on some floors is omitted. It is an easy matter to give the deduction when listed separate.

Now, having listed the stairs as you came up to the next floor, you walk outside and commence to list windows as described for the basement. Repeat this operation for all floors. Always note the floor you are listing at the head of the material list.

You will find it will help you materially if you imagine yourself actually on the job measuring up and listing the work. You must have a mental picture of the building and see it as clearly in your mind as you see the rooms in which you live.

There are miscellaneous items in connection with this type of building that will be specified and shown on the plans, such as:

Roofing, Angle Iron, Iron Grills, Gratings, etc.

Sheet Metal, Cement Walks and steps, Stone Work, etc.

I will now give a few examples in the use of labor constants without further mention of methods in listing.

EXCAVATION.

Ordinary dirt excavation—material to be hauled to dump half mile from building site.

MAIN EXCAVATION.

(See Table, Page 1.)

2,500 cu. yd., figure cost as follows:

Plow team, 2,500 x .10	250 hours
Team time loading and dumping, 2,500 x .30	750 hours
Team time traveling to dump and back, 2,500 x .50	1,250 hours
Extra snatch team for, 800 x .10	80 hours
Total team hours	2,330 hours
Extra man holding plow	250 hours
Labor shoveling into wagon, 2,500 x .98	2,450 hours
Total labor hours	2,700 hours
Total team time, 2,330 hours, at $1	$2,330.00
Total labor hours, 2,700 hours, at $0.40	1,080 00
Total cost of excavation	$3,410.00

At the above scale of wages, this excavation figures approximately, $1.36½ per cu. yd.

If the above was hauled over paved streets you would reduce the hauling time 25 per cent, therefore, since the traveling time cost 1,250 hours, or $1,250, it would reduce the hauling cost $312.50.

SHEET PILING.

Suppose the above excavation were 20 feet deep at the alley and it was necessary to use sheet piling. For an example, say the width is 50 feet and the depth 20 feet, this would figure 1,000 square feet of bank to be held.

Table on page 2 of the Constants for 20 feet deep gives 7 feet lumber board measure for each square foot bank, therefore:

1,000 x 7—7M feet B. M., say at $40		$280.00
Labor as follows:		
1,000 x .04—40 hours carpenter, at $0.80	$32.00	
1,000 x .24—240 hours laborer, at $0.40	96.00	
1,000 x .02— 20 hours foreman, at $1	20.00	
Total labor cost		$148.00
		$428.00
Salvage on lumber, 50 per cent 3,500 ft., at $30		105.00
Estimated net cost		$323.00

At the above prices of labor and material the cost per square foot is 32⅓c.

CONCRETE FOUNDATION WALLS AND FOOTINGS.

326 cubic yards, mixed 1:2:4

Material

326 x .90—293 cu. yd. gravel, at $2	$ 586.00	
326 x .45—146 cu. yd. sand, at $1.50	219.00	
326 x 6—1,956 sacks cement, at $0.80 net	1,564.80	
Water for 326 yards, at $0.10	32.60	
		$2,402.40

Labor.

See Table, Page 3, Constants.

Using small mixer.

326 x 2.25—733½ hr. common labor, at $0.40	$293.40	
326 x .20—65 hr. mixer and engineer, at $2	130.00	
326 x .20—65 hr. foreman, at $1	65.00	
		$ 488.40
Total cost material and labor		2,890.80

At the above price of material and labor, the cost per cu. yd. is approximately $8.25.

WALL FORMS.

17,564 sq. ft. wall forms, wall surface measure.

Material.

(See Table, Page 4A.)

17,564 x 1.16—20,374 ft. sheathing, at $40	$ 814.96	
17,564 x .84—14,754 ft. studs and bracing, at $35	516.49	
17,564 x .03—527 lb. wire, at $0.07	36.89	
17,564 x .005—88 lb. com. nails, at $0.06	5.28	
	$1,373.62	
Salvage on lumber, 60 per cent—21,000 ft., at $25	525.00	
Net cost material	$ 848.62	$848.62

Labor.

See Table, Page 4, Ordinary Wall Forms.

Approximately 35,000 ft. B. M. to erect and wreck.

35,000 x .019—665 hr. carpenter, at $0.80	$532.00	
35,000 x .005—175 hr. laborers, at $0.40	70.00	
35,000 x .012—120 hr. wrecking, at $0.40	168.00	
35,000 x .002— 70 hr. foreman, at $1	70.00	840.00
		$1,688.62

Cost per sq. ft. at the above prices, approximately 9½ ct. sq. ft.

If there are pilasters in the above wall forms, use the constants given for pilasters, and add to the above labor hours.

225,000 Engineers, Architects and Draftsmen in United States

According to the 14th census in 1920 there were 64,660 civil engineers and surveyors in the United States as compared with 52,033 in 1910. The total number in the professional technical class, according to the census report, was 224,957 made up of the following:

	1920.	1910.
Architects	18,185	16,613
Designers	15,410	11,788
Draftsmen	52,865	33,314
Inventors	2,376	2,347
Civil engineers and surveyors	64,660	52,033
Electrical	27,077	15,278
Mining	6,695	6,930
Mechanical (including all others)	37,689	14,514
Total	224,957	152,817

The above figures for 1920 include 7,842 women for all but 178 of whom were designers, draftsmen or inventors. The total for 1910 includes 6,283 women.

Design of Concrete Mixture Without Use of Abrams' Tables

By H. C. BOYDEN,

Portland Cement Association, 111 West Washington St., Chicago.

Four variables must be considered in the design of a concrete mixture, as follows:

1. The quantity of the cement (the mix).
2. The plasticity (the slump).
3. The water-cement ratio (the quantity of water).
4. The grading of the aggregate (fineness modulus).

When any two of these variables are fixed it becomes impossible to vary a third without varying the fourth.

Consider the steps required to design without the use of Abrams' Tables of Proportions and Quantities*, a concrete mixture for a desired strength, with known aggregates. Many other problems will come up, but it is believed that this will be the most common. An understanding of the steps required, for the solution of this particular problem will serve in the solution of others.

The term known aggregates, does not mean only one of

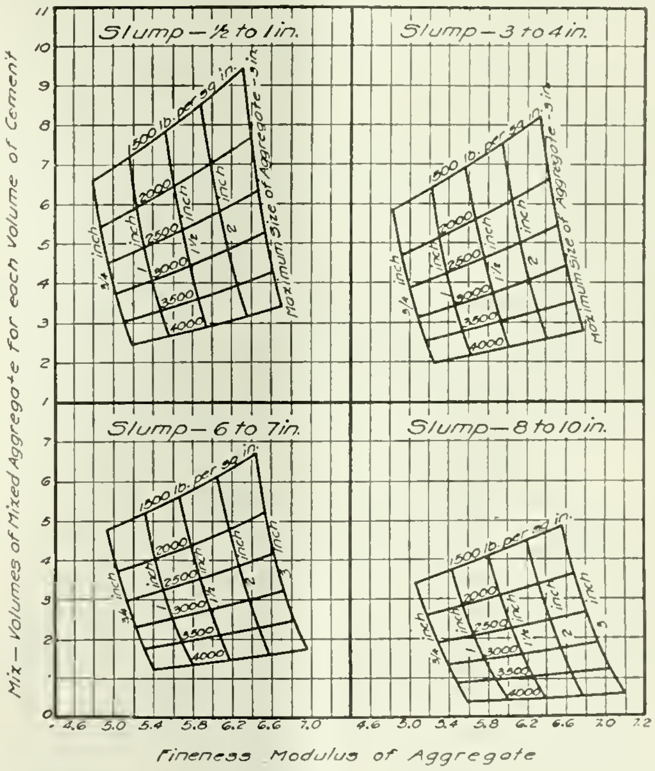


Fig. 1—Relation of Size and Grading of Aggregates and Quantity of Cement to Strength of Concrete.

Based on relation between strength and quantity of mixing water shown in Fig. 3 and relation between quantity of mixing water and fineness modulus of aggregate shown by equation in Step 8.

The lines sloping upward to the right show the relation between quantity of cement (the mix) and the grading of aggregate (the fineness modulus) for a given strength and consistency.

The lines sloping upward to the left give the maximum value of fineness modulus which may be used for an aggregate of a given maximum size for different mixtures to obtain a workable concrete. (For method of determining maximum size, see explanation of tables in Bulletin 9—Structural Materials Research Laboratory, Lewis Institute, Chicago.)

Values from chart should be used only for aggregate having o—No. 4 sand as a fine aggregate. The following quantities of cement should be added to the values found on the diagrams for sands of different size:

Size of sand.	Cement added to correct for size of fine aggregate per cent.
o-28	12
o-14	8
o-8	4
o-4	o
o-⅜	—4

---

*See Bulletin 9, Structural Materials Research Laboratory, Lewis Institute, Chicago, 1921.

each class; there may be several of each available, in which case the problem is worked out for any or all of the combinations desired.

Known—Sand (fine aggregate).

Stone (coarse aggregate).

Strength (desired).

To be Determined—Plasticity (governed by construction needs for each job).

Mixture (controlled by plasticity, strength and size of aggregate).

Water-cement ratio (controlled by desired strength).

Quantities of ingredients per cu. yd. of completed concrete.

Assume for this particular problem a sand graded from 0 to No. 8 sieve and a crushed stone graded from No. 4 sieve to 2 in. and that concrete with a compressive strength of 3,000 lb. per square inch at 28 days is desired.

Step 1. Determine upon the plasticity, as indicated by the slump.—This is determined by the actual knowledge of the slumps required for concrete in order that it shall be economically workable. Note: For a given aggregate within the range of plastic mixtures, increased plasticity or workability for the same strength, may be obtained only by adding water and cement in such proportions as to maintain the same water-cement ratio as that giving the desired strength.

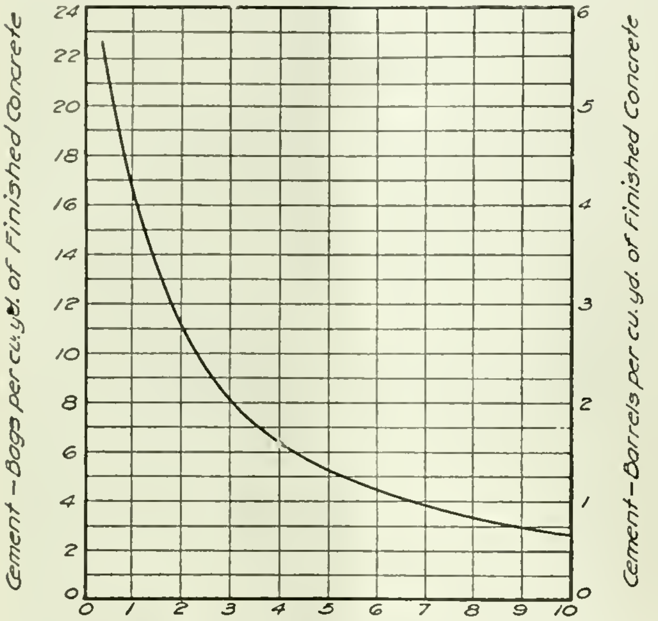


Fig. 2.—Cement for 1 Cu. Yd. Finished Concrete.

(Assume for this problem that the concrete is to be used for road construction with mechanical tamping. This type of construction will permit the economical use of a concrete having a ½ to 1 in. slump.)

Step 2. Determine the real mix and the fineness modulus of such a mix.—(The nominal mix of 1:2:4 would have a real mix of about 1:5 or one volume of cement to five volumes of aggregate.) The calculations required for the solution of this step are somewhat involved; in order to simplify the work, four charts (Fig. 1) have been plotted, a separate chart for each range of slumps used in Abrams' Tables. Each of these charts has four variables: Strength, maximum size of aggregate, number of volumes of mixed aggregate for one volume of cement (the mix) and the fineness modulus of the mixed aggregate to be used. With any two of the above variables known the remaining two factors can be obtained. Using the chart for ½ to 1 in. slump and the intersection of the 3,000 lb. per square inch strength contour with the 2 in. maximum size of aggregate contour, the abscissa indicates a fineness modulus of 6.2 and the ordinate a mixture of 1:4:8 which is the real mix.

In the explanation under Fig. 1, attention is called to the fact that corrections to the values shown on the charts must be made where sands other than 0 to No. 4 are used, therefore for this example, due to using 0 to No. 8 sand, we must add 4 per cent the amount of cement indicated by the 1:4.8 mix. The mix then becomes 1:4:.6.

Step 3. Sieve analysis and fineness modulus.—Make a sieve analysis of each aggregate with set of sieves of U. S. Standard sizes and determine its fineness modulus, by adding together the percentages of the total aggregate (preferably by weight) coarser than each sieve, and dividing the sum of these percentages by 100. (Assume for this problem the fineness modulus of the sand to be 2.5 and of the crushed stone, 7.3.)

Step 4.—Calculate the radio of the volume of the fine aggregate the sum of the separate volumes of fine and coarse aggregates.—Use the following formula:

$$r = \frac{Mc - M}{Mc - Mf}$$

r=Ratio of volume of fine aggregate to the sum of separate volumes of fine and coarse aggregate.

Mc=Fineness modulus of coarse aggregate.

Mf=Fineness modulus of fine aggregate.

M=Fineness modulus of mixed aggregate.

We determined in step 2 that a fineness modulus of 6.2 was required for the assumed conditions. The formula then becomes

$$r = \frac{7.3 - 6.2}{7.3 - 2.5} = 0.23.$$

In other words 23% of the total aggregate is sand and 77% (1—r=0.77) is broken stone.

Step 5. Determine the ratio of the volume of mixed aggregate, of the proportions determined, to the volume of the fine and coarse aggregate measured separately.—This denotes the yield of aggregate after mixing. This factor can best be determined by tests on the aggregates to be used. Find the weight per cubic foot of fine, coarse and mixed (in determined proportions) aggregates. (Note: Aggregates should be room dry and measured in a ½ cubic foot cylindrical measure with height equal to diameter. Place aggregates in the measure in three layers, rodding each layer 30 times with a pointed ⅝ in. metal rod, then heap and strike off level with top.) Use the following formula:

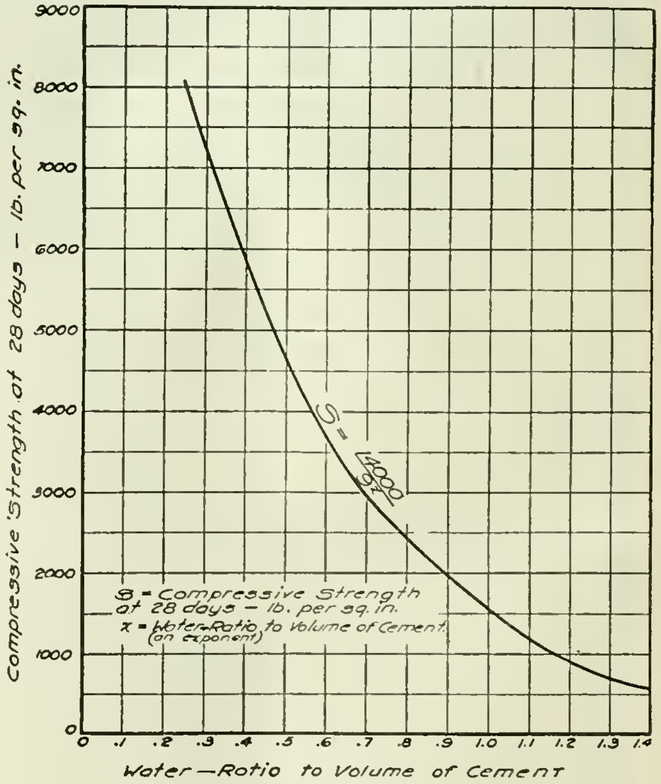


Fig. 3.—Effect of Quantity of Mixing Water on Strength of Concrete.

$$Ya = \frac{(r \times Wf) + (1 - r)\ Wc}{Wm}$$

Ya=Ration or yield.

r=Ratio of fine aggregate from step No. 4.

Wf=Unit weight of fine aggregate.

Wc=Unit weight of coarse aggregate.

Wm=Unit weight of mixed aggregate.

For our example we will assume the sand to weigh 108 lb.

per cu. ft., crushed stone to weigh 105 lb. per cu. ft., mixed aggregates to weigh 123 lb. per cu. ft., and on substituting we have:

$$Ya=\frac{(0.23 \times 108)+(1-0.23)\,105}{123}=0.86.$$

Or for these conditions 0.23 cu. ft. of sand mixed with 0.77 cu. ft. of coarse aggregate will give a total volume of 0.86 cu. ft. of mixed aggregate.

Step 6. Determine the nominal mix.—From Step 2 we find the real mix to be 1:4.6, or 4.6 volumes of mixed aggregate to 1 volume of cement.

Using the ratio Ya found in Step 5 we find the volume of the fine and coarse aggregates measured separately to be $\frac{4.6}{0.86}$

Therefore:

Volume of sand=0.23 (Step 4) x 5.30=1.2

Volume of crushed stone=0.77 (Step 4) x 5.30=4.1 and the Nominal Mix=1:1.2:4.1.

Step 7. Determine the quantities of each ingredient per cubic yard of concrete.—This is most easily accomplished by using Fig. 2, which is based on actual quantities determined in the laboratory from various mixtures. Using the Real Mix (Step 2) of 1:4.6 we find that 5.73 bags or 1.43 bbl. of cement is required for each cubic yard of finished concrete.

Then:

5.73 x 1.2 (Step 6)=6.9 cu. ft.=0.25 cu. yd. of sand per cu. yd. of concrete.

5.73 x 4.1 (Step 6)=23.6 cu. ft.=0.87 cu. yards. of stone per cu. yd. of concrete.

Step 8. Determine the water-cement ratio for the above mixture.—There are two methods for this determination, one by the use of Fig. 3, the other by determination in the field from actual concrete mixed in the proper proportions and giving the desired slump. The latter method is recommended, as it will give the amount of water required under field conditions and will automatically take care of the absorption and water content of the aggregates. This quantity can be checked by the use of Fig. 3, remembering that the diagram is based on room dry aggregates and does not take into account either the water absorbed by or the moisture content of the aggregates.

If a further check is desired, the net quantity of water required to produce the desired strength may be calculated from the following equation.

$$X=R\left(0.35+\frac{(0.22-M)\,N}{42}\right)$$

X=Volume of water required (ratio to volume of cement in a batch; one sack of cement assumed to be 1 cu. ft. and to weigh 94 lb.)

R=Relative consistency desired in the concrete.

1.00 gives slump of ½ to 1 in.

1.10 gives slump of 3 to 4 in.

1.25 gives slump of 6 to 7 in.

1.50 gives slump of 8 to 10 in.

M=Fineness modulus of the mixed aggregates (See Step 2).

N=The mix (Volume of mixed aggregate to one volume of cement (See Step 2).

Therefore in our example:

$$X=1.0\left(0.35+\frac{(0.22-6.2)\,4.6}{42}\right)=0.67$$

$$=7.48 \text{ (U. S. gal. per cu. ft.)} \times 0.67=5.00.$$

(U. S. gal. of water per sack of cement.)

The amount of water to be added because of the absorption and to be subtracted because of the water already contained in the aggregate can, if desired, be determined by actual experiment, but certain approximations are believed to be sufficiently accurate.

R. B. Young in the Engineering News Record of Jan. 1, 1920, states that, "In calculating the water, allowance must be made for moisture contained in the aggregate in its natural state. This has been found to be seldom less than 2 per cent and usually between 3 and 4 per cent. This last is a safe figure to use except directly after a rain, where six or eight per cent moisture should be allowed for and it is believed that these allowances will cover average construction conditions."

The absorption of various aggregates may be determined in accordance with Recommended Practice American Society for Testing Materials 1920 Proceedings Pt. 1 Appendix 1, or average quantities may be assumed to be as follows:

Average sand 2.0% by Volume.

Pebbles and crushed limestone 2.0% by Volume.

Porous limestone 8.0% by Volume.

Very light and porous aggregate may be as high as 25.0% by Volume.

It may be found that the mixture designed, when used with some aggregates, will be too rough to work easily, and a smoother mixture of the same strength may be desired. The usual custom in this case, is to add sand to the mixture. This, however, will reduce the strength of the concrete unless more cement is added to maintain the same water-cement ratio, as the addition of sand will require more water to give the same plasticity.

A new mixture must be designed as follows: Assume that we wish to increase the sand in our mixture from 0.23 to 0.33 which either judgment or experience tells us will give the proper workability. Our present mix has a fineness modulus of 6.2 and increasing the sand to 0.33 will reduce the stone to 0.67 and change the fineness modulus to 5.7 as determined by following formula:

$$M=Mf \times r+(1-r)\,Mc.$$

$$=2.5 \times 0.33+(1-0.33)\,7.2.$$

$$=5.7.$$

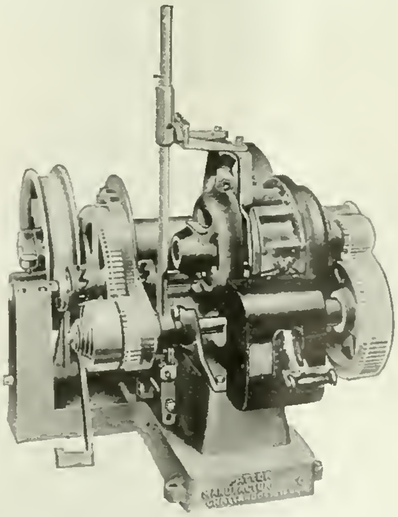
Then from Fig. 1 with a fineness modulus of 5.7 and a strength of 3,000 lb. we find the new mix to be 1:4.4. With this new mix the yield, nominal mix, etc., can be figured in the same manner as outlined above.

For the working out of further problems in concrete mixtures reference is made to Bulletin 1 of the Structural Materials Research Laboratory, also to the article on "Examples of the Application of Abrams' Water-ratio to Proportioning Concrete" by Stanton Walker, published in the Proceedings of the American Concrete Institute Volume XVI, 1920. It is believed that any problem liable to come up in the design of concrete mixtures, may be solved by the intelligent use of the information presented here and in these publications.

New Combination Reversible Hoist

A new combination reversible hoist with interchangeable power plants has been placed on the market by the Patten Manufacturing Co., Chattanooga, Tenn. The first of this type hoist was built in August, 1920, and the model has been in continuous test operation since that time.

The hoist is equipped with winch head, drum and reversible sheave for operating double cages. Power is transferred to the hoist through a multiple disc clutch, which runs in oil. The forward drive is through machine cut spur gears and the reverse drive by a silent chain. A special feature is the automatic mid-motion stop on the operating lever. This prevents inexperienced operators from suddenly reversing the machine. Another worth-while feature is that the engine and motor are interchangeable on the same bed. This change can be made in a few minutes by an inexperienced man. The hoist is built to the duplicate parts system, jigs and templates being used throughout. Only one size is built which enables the manufacturer to standardize his production. The hoist is operated by a standard electric motor of 5 HP. gasoline-Kerosene engine.—(New-Way.)

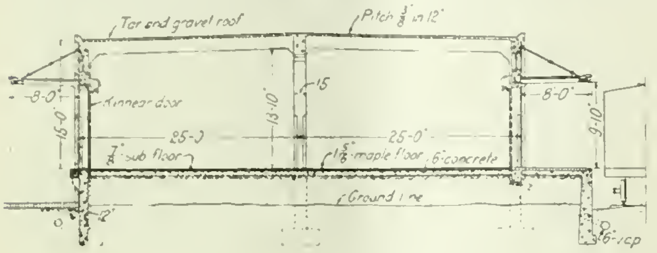


Type K, Combination Reversible Hoist.

New Katy Fire Proof Construction Freight House at Dallas, Tex.

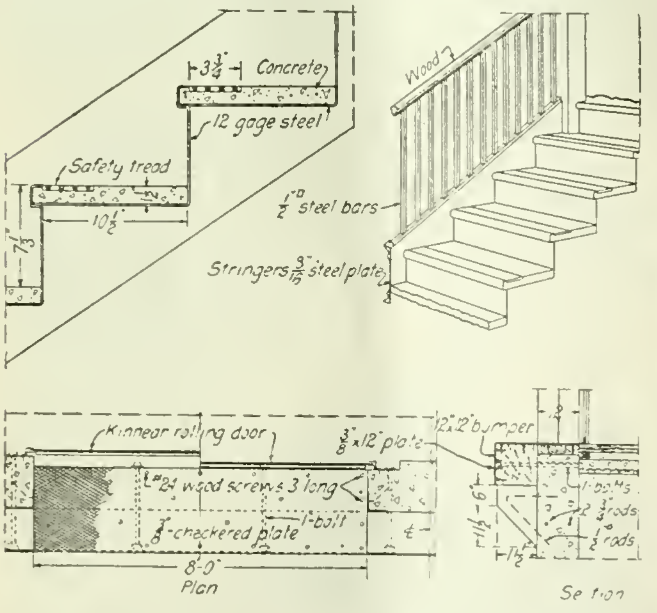
A new freight house, having a number of interesting features, was completed recently at Dallas, Tex., for the Missouri, Kansas & Texas Ry., at a cost of about $350,000. The following information regarding this improvement is taken from the Railway Age:

The new house is 600 ft. long by 50 ft. wide and one story in height except 100 ft. of the south end, which is two stories high, the second story and the south 20 ft. of the first floor being used for offices, stairways, toilet rooms, etc. An 8-ft. platform is provided along the track side of the warehouse, and in addition there is an open platform 100 ft. long by 58 ft. wide at the north end.



Section Through the Warehouse.

The building is of fireproof construction throughout. The ground floor is supported on a concrete slab, which rests on a fill enclosed by retaining walls, except for a small basement to house a heating plant at the south end of the building. The frame of the structure is of reinforced concrete with a reinforced concrete slab for the roof and for the second floor and a portion of the first floor over the basement. The north end of the warehouse and the south end and second floor of the office building are enclosed with brick walls, with wire-glass windows set in standard sheet metal fireproof sash and frames. In the warehouse, owing to the maximum utilization of wall space on the team and track side for doors and windows, the brick work was superfluous, and only the concrete lintels, columns and girders are exposed to view between the wall openings, which are fitted with Kinnear rolling doors with wire glass in Fenestra sash in the transoms. The stairways consist of No. 12 gage pressed steel treads and risers, carried by stringers of 3/16 in. plates. The treads are covered with 1½ in. of concrete and are fitted with Mason safety treads. The office space on the second floor is provided with a plaster ceiling on wire lath and metal joists, suspended by metal hangers from the reinforced concrete roof frame.



Details of Metal Stairway and of the Sill Construction for the Driveway Doors.

The building is supported on natural foundations at a depth of a few feet below grade. The warehouse floor and the platforms are at a level of 3 ft. 10 in. above the top of rail. Inside the house and concrete floor is covered with a 1 5/16 in. maple floor with a ⅞ in. sub-floor, carried on 2 in. by 4 in. sleepers imbedded in the concrete. On the platforms creosoted wood blocks take the place of planking.

The concrete framing of the superstructure consists of three lines of columns spaced 20 ft. longitudinally and spanned by longitudinal girders. These in turn support transverse beams spaced 6 ft. 8 in. center to center, which carry the roof and floor slabs. For the warehouse doors the 20 ft. panels are cut in two by 12- in. by 12-in. concrete door posts, leaving two openings 8 ft. wide by 9 ft. high for the rolling doors. All columns and door frames in the warehouse are protected at the corners by 6-in. by 6-in. steel angles extending to a height of 6 ft. above the floor. Along the roadway side of the building a 12-in. by 12-in. bumper timber is provided, supported on reinforced concrete brackets. This timber is covered by a ⅜-in. plate, the top sheet being a diamond pattern safety floor plate.

The doorways along the roadway side and the platform on the track side are protected from the weather by a continuous canopy projecting 8 ft. from the wall. This canopy is of frame construction, covered with ⅞-in. tongue and grooved boards and the entire frame is supported from the building by ⅞-in. tie rods anchored into the wall. The roofs of the building are covered with tar and gravel sloping from the longitudinal center line each way to gutters along the two sides of the building, having external downspouts at intervals of 40 ft.

Warehouse scales with platforms 4 ft. 8 in. by 7 ft. 6 in. are installed on the center line of the freighthouse at intervals of 80 ft. and an automobile scale with a platform 9 ft. by 20 ft. is provided on the platform at the north end where a crane has also been installed to handle heavy shipments. At every fifth column on the center line of the building a fire hose is provided with connection to a Volkhardt valve and base installed in a pit below the floor.

How Steel Sash Stood Up in Factory Fire

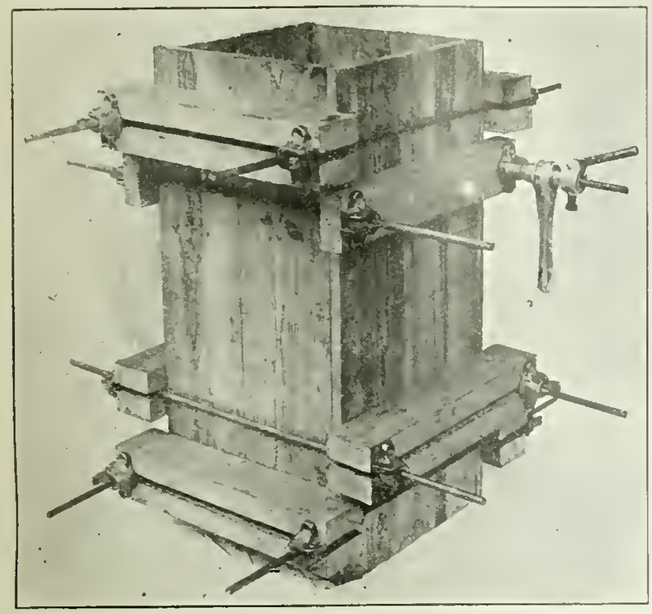
The fire resistive qualities of steel sash were well brought out by a fire on March 21 at the Portland Flouring Mills, Portland, Ore. The conflagration raged for more than 6 hours and the firemen say it was the hottest fire in their experience. The interior view, reproduced below, shows the conditions at a point when the fire was hottest. Despite the intense heat, which melted the electrical conduits and cracked the wire glass, all the Truscon steel sash were intact and could be opened on their own hinges. A few of the mullions buckled but the sash remained in place.

Interior View Showing Condition of Steel Sash.

Convention of American Concrete Institute.—The next convention of the Institute will be held at the Hotel Sinton, Cincinnati, O., Jan. 22-25, inclusive.

A New Form Clamp

A perfected form clamp has been brought out by the Victor L. Phillips Co., 7th and Delaware Sts., Kansas City, Mo. The clamp is easily placed on the form. The only tool required is a ratchet tightener. It is stated that any laborer can put on the clamps as easily as a mechanic, and that they cannot come loose, as the harder the stress, the tighter they grip.



New Form Clamp.

They can be used on both walls and columns, any thickness or any size. The ratchet tightener makes it possible to work up against another wall or in very close quarters with great speed.

New Roofing Kettle

A roofing kettle, having a number of new features, has been placed on the market by the Barber Asphalt Co., Philadelphia. Among the advantages claimed for this kettle are quick heating of the asphalt and small fuel consumption. It is stated

100 Gal. Iroquois Continuous Roofing Kettle.

that asphalt can be heated ready for the roof within 10 minutes after the kettle is started and that less than 10 lb. of fuel are required for each 100 lb. of asphalt melted. The continuous feature of the kettle is secured by the arrangement of the side pockets for the cold asphalt, where the material is warmed and from which it flows into the bottom of the tank, giving a supply of hot asphalt as long as the fire is kept burning. The cold material never comes in contact with hot material. The casing is made of No. 14 sheet steel, is 38½ in. wide inside, 54 in. long, and 36 in. high. The tank is made of No. 10 sheet steel, is 23 in. wide inside, 49¾ in. long, and 23 in. deep.

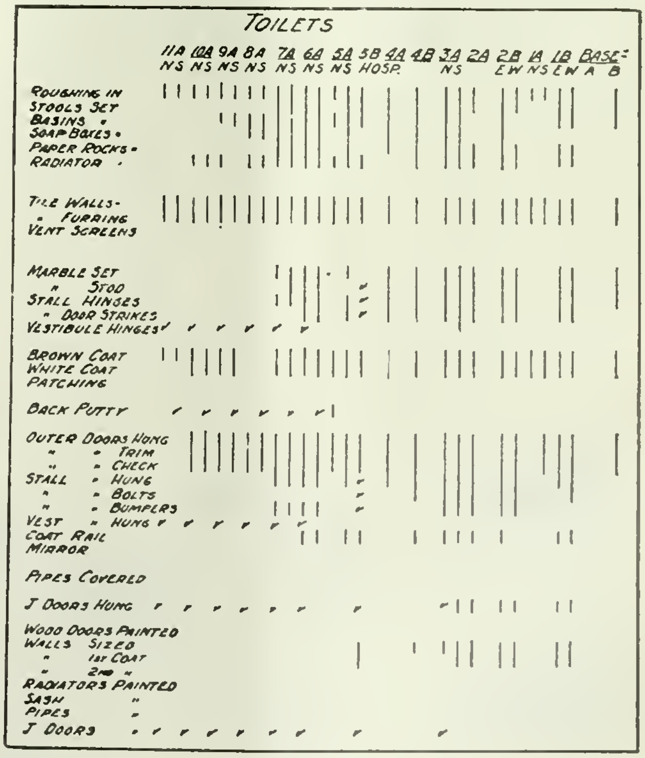
Checking Completion of Details in Building Construction

A general superintendent for a building contractor, traveling about from job to job, often finds great difficulty in checking the completion of details. Particularly is this true as work nears completion, or when the owner has taken partial occupancy. There are often a myriad of items yet to be cared for which require some means of following up other than inspection and memory.

Wells Brothers Construction Co., Chicago, makes use of check sheets, which permit quick analysis of progress. The illustration, reproduced from Concrete shows a check sheet used on work of the National Cloak & Suit Co, at Kansas City, an 11-story warehouse of 690,000 sq. ft. of floor, which was occupied with a full force while considerable work remained to be done. The owners desired the quickest possible cleaning up in order to avoid constant hindrance to efficient operation.

The check sheet shown covers the item of "toilets," which always require considerable watching. At the left are itemized the details, and across the top are column heading 11-A, 10-A, 9-A, etc., representing floor in "A" and "B" building, and the N. and S. refer to north toilet and south toilet, respectively. In each column a vertical heavy line indicates the work as completed, a check mark indicates absence of that detail in that particular toilet, and a blank shows work yet to be done.

When the general superintendent demands records of this sort from the superintendent, and the superintendent on the job follows these sheets for daily execution, there is nothing left to memory, and if there is blame for non-execution it can be put on the right shoulders.

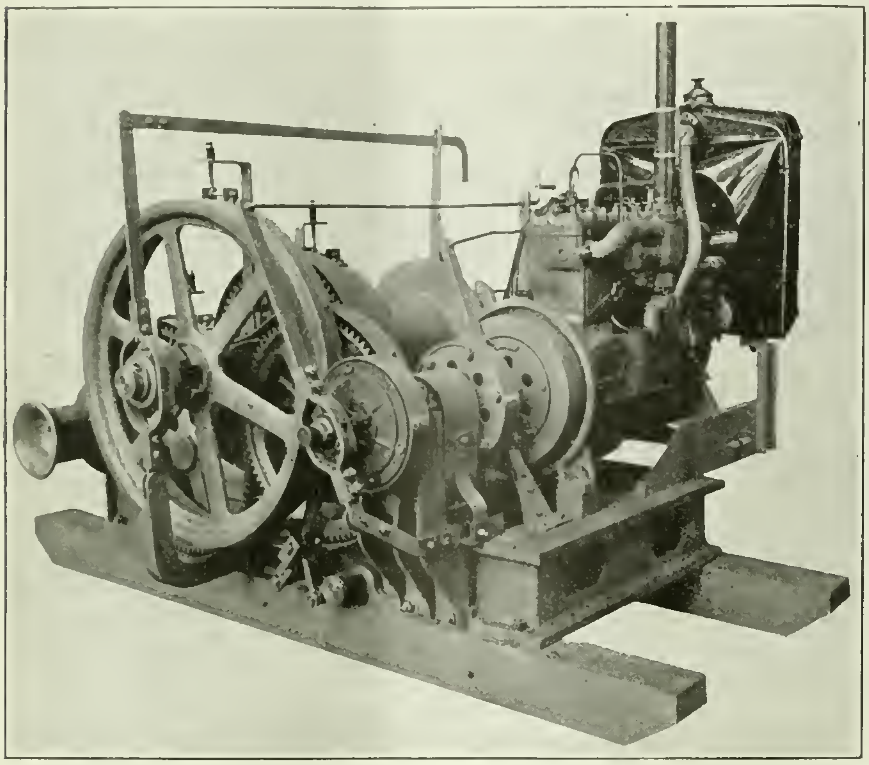

TOILETS
11A NS
10A NS
9A NS
8A NS
7A NS
6A NS
5A NS
5B HOSP.
4A
4B
3A NS
2A
2B EW
1A NS
1B EW
BASE= A B
ROUGHING IN
STOOLS SET
BASINS "
SOAP BOXES "
PAPER ROCKS "
RADIATOR "
TILE WALLS-
" FURRING
VENT SCREENS
MARBLE SET
" STOO
STALL HINGES
" DOOR STRIKES
VESTIBULE HINGES
BROWN COAT
WHITE COAT
PATCHING
BACK PUTTY
OUTER DOORS HUNG
" " TRIM
" " CHECK
STALL " HUNG
" " BOLTS
" " BUMPERS
VEST " HUNG
COAT RAIL
MIRROR
PIPES COVERED
J DOORS HUNG
WOOD DOORS PAINTED
WALLS SIZED
" 1ST COAT
" 2ND "
RADIATORS PAINTED
SASH "
PIPES "
J DOORS

Sheet for Checking Details.

Colored pencils may be used to show progress as between weeks, black for the initial week of the record and a new color for each succeeding period.

New P. & H. Elevator Hoist

To the contractors' hoist and derrick line built by the Pawling & Harnischfeger Co. of Milwaukee has been added a gasoline-operated elevator hoist for double elevator work.



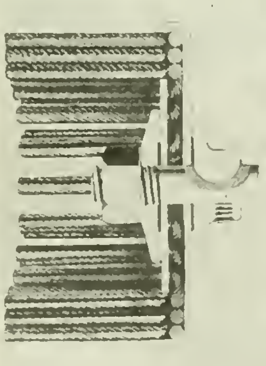
Two-Drum Type Hoist.

The standard contractor's hoist may now be obtained, equipped with an elevator sheave in place of the nigger head on the back drum. Reversing is accomplished by means of friction clutches. An endless rope passes around the elevator sheave, then over guide sheaves and elevator head sheaves to the up and down elevators. The elevator sheave operates through a jaw clutch and works independent of the main drums. The main drums can be used for other purposes at any time.

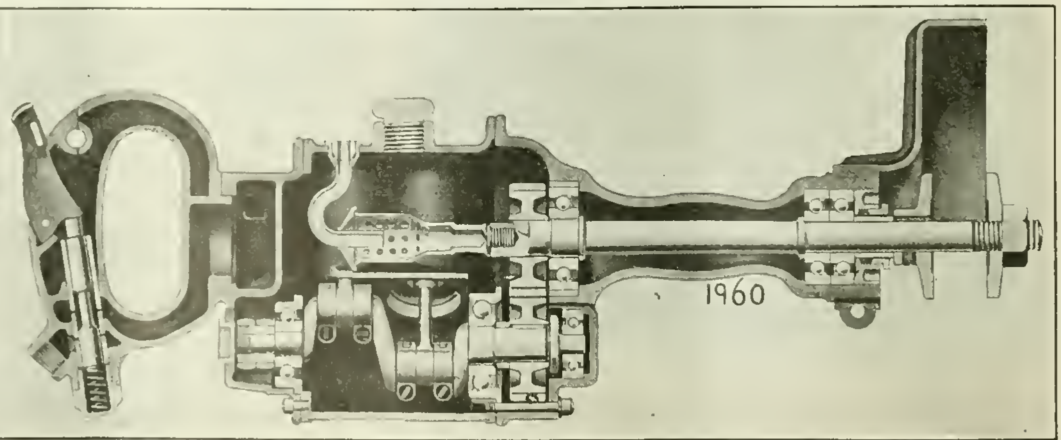
The hoist shown in the illustration is the 2-drum type J-50 equipped with a 5x6¼ Waukesha motor. The single line pull of this unit is 5,000 lb.; hoist speed, 185 ft. per minute; elevator sheave speed, 500 to 550 ft. per minute, with a rated load of 1,000 lb.

Oil Separator and Wire Brush for Air Grinders

When the air grinder was first made its service was more or less intermittent. Since then its field of utility has widened into such jobs as removing rust from structural steel work which is to be encased in concrete. In the automobile field, grinders are used for removing rust and light scale from frames and bodies. Cleaning gondola steel cars is another example of why present-day conditions make necessary the continuous use of air grinders. And since most grinder users customarily oil their grinders once or twice daily, both manufacturers and users of air grinders have been seeking a method for keeping such tools supplied with lubricant for longer periods. To that end the Chicago Pneumatic Tool Co., New York, has devised what is known as the oil separator which is applicable to Little Giant air grinders, and which, it is claimed, permits the operation of air grinders continuously for 48 hours or longer without replenishing the supply of lubricant. The oil separator consists of a hollow perforated cylindrical steel shell attached at one end to the grinder spindle and at the other end encircles and revolves around the vent tube. As the oil-laden air enters the holes in the oil separator the centrifugal action of the oil separator, revolving at spindle speed, instantly separates the oil from the air, permitting the air to escape, oil-free, through the vent tube and preventing oil leakage. It is estimated by the manufacturers that the oil separator saves $90 annually in lubricating expense because, it is said, it makes oiling necessary only once weekly instead of daily as has heretofore been the practice among most users of air grinders. The oil separator is applicable to the larger sizes of Little Giant air grinders and can be attached to such grinders now in use. Inasmuch as the air grinder is used for removing rust and old paint, the Chicago Pneumatic Tool Co. announces the advent of a new wire brush which consists of three units—a ⅛ in. back plate dished as shown; a ⅛ in. front plate with a series of slots; a wire brush consisting of 30 renewable units made of heat-treated crucible steel.



The New Wire Brush.



The Oil Separator for Use With Air Grinders.

Personals

W. H. Steiner has been appointed district engineer in charge of the Des Moines office of the Portland Cement Association to succeed H. L. Tillson, resigned. This office, located in the Hubbel Bldg., has charge of association work in Iowa. Mr. Steiner has been connected with the Portland Cement Association for the past three years, spending all that time in Iowa. Prior to joining the association staff, he was city engineer of Marshalltown, Ia., for 10 years, and with railroad companies 7½ years. During the World War Mr. Steiner served as first lieutenant of engineers.

The Austin Co., Builders and Engineers, Cleveland, O., has opened a branch office in the L. C. Smith Bldg., Seattle, Wash., with G. W. Plaisted as local manager.

Arthur M. Greene, formerly professor of mechanical engineering in the University of Missouri, has been elected dean of the School of Engineering at Princeton University.

The Binghamton Engineering Co., recently organized at Binghamton, N. Y., with A. L. Gilmore as president and Geo. H. Young as treasurer, has opened offices at 777 O'Neil Bldg., for conducting a steel and iron business. This company is specializing in the design, fabrication and erection of structural steel.

Roads and Streets Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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E. & C. Index Furnished Only on Request

The index for Vol. LVII—January-June, 1922—issues of Engineering and Contracting will be ready for distribution shortly. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Ancient Costs of Transportation

Roger's "History of Agriculture and Prices in England" contains some interesting data on the cost of hauling during the middle of the fourteenth century. It is necessary to multiply wages and prices of that period by about 3.33 to reduce them to the gold standard of today, for the weight of gold in the present pound sterling is now less than one-third what it then was. Performing this multiplication we have the following prices in 1334 to 1346:

Price of a horse	$17.00
Wages of driver with two horses and a cart, per day	.50
Wage of laborer, per day	.17
Wage of carpenter, per day	.25

This indicates that the wage of a driver was about the same as the rental of a horse.

Rogers adds 25 per cent to the air-line distance between cities to get the average distance by roads. The price of hauling grain was ordinarily about 6.7 ct. per ton mile. This indicates that about 7.5 ton-miles were hauled per team and driver per day, and probably that a team traveled 15 miles a day, going loaded and returning empty. Occasionally the charge for hauling was half that above given, but Rogers suggests that this may be ascribed to off-season work when havesting was not in progress.

Rogers says that charges for hauling in boats on rivers and along the coast averaged about one-sixth as much per ton-mile as hauling by carts. He cites a 60-mile haul by boat up the Thames River for 1.3 ct. per ton-mile. He says that there are very few places in England that are more than 50 miles from some navigable river, or more than 80 miles from the sea.

It has been customary to argue that daily wages would buy almost as much in those ancient days as now, and that therefore the workers were almost as well off then as now. But a study of Rogers' monumental treatise on prices and wages dispels any such illusion. At the very time that laborers received 17 ct. a day, wheat was 50 ct. a bushel, and other farm crops and clothing in proportion. Adam Smith, in his Wealth of Nations, remarks that wheat was the greatest staple used by workers in England in the middle ages and even down to the time that he published his book, 1776. Wheat today is about twice as expensive as it was 500 years ago; but the daily wages of the average laborer are 20 times what they were then.

The startling fact is that nearly the entire increase in buying power of wages has occurred since Adam Smith wrote his Wealth of Nations in 1776, the present buying power of the average American daily or weekly wage being five times what it was when our Declaration of Independence was signed.

Chicago's Eighteen Municipal "Experts" Go to Europe

Our readers will be delighted to know that 18 of the leading municipal experts of America have been sent to Europe at the expense of the city of Chicago. The 18 are so well known to municipal engineers that merely to name them will be sufficient assurance that their reports on European pavements, sewers, climate and scenery will be eagerly awaited by every municipal engineer in America. The members of this investigating committee are Mulcahy, Toman, Coughlin, Hogan, Powers, Agnew, Moran, Kavenagh, Jensen, Klein, Lynch, Govier, Devereux, Cepak, Rutkowski, Czekela, Kovarik, and Adamowski.

In addition to being experts on municipal engineering, these men are members of the Chicago City Council committee on streets and alleys, and are thus doubly qualified to prepare a report on European highways that will, we doubt not, revolutionize American engineering practice.

Chicago has unfortunately shown its usual parsimony by giving these aldermen only $19,500, or barely $1,080 each, with which to defray the expenses of this trip.

City Engineer Murdoch was not invited to accompany the 18 aldermanic experts, we understand, possibly on the theory that an engineering education would so greatly hamper him as to make his conclusions useless, but more likely on the theory that an engineer could easily learn from books and magazines all that pertains to streets and alleys, whereas an aldermanic highway expert must see things with his own eyes. And, after all, there is merit to this latter theory, for not every alderman can read an engineering description or interpret an engineering drawing.

The trip is not to be entirely given over to a study of streets and alleys. One of the Chicago daily papers tells us that "Incidentally the aldermen will take a trip down the Rhine, give the Alps the once over, glimpse the war-riven territories, and get a chance to see by comparison whether prohibition is a success in the United States."

The committee has issued a proclamation for the benefit of any taxpayers who might question the necessity of sending 18 aldermen to do what is normally regarded as the work of one man—the city engineer. The proclamation contains 47 reasons for the 18-man-power trip, beside the two obvious reasons (1) a study of streets and (2) a study of alleys. The 18 aldermen belong to 12 other committees, and Europe is expected to assist them in solving Chicago problems in every one of the 13 branches of aldermanic committee work. We don't know the province of each of the 12 committees, but in a city as large as Chicago the wonder is not that there are only a dozen committees, but rather that there are not a gross.

From Adamowski to Mulcahy we extend a hearty bon voyage a la carte blanche au Chicago.

$271,000,000 of Road Contracts Let First 6 Months of 1922

The following weekly summary was written by the editor of Engineering and Contracting for the Chicago Journal of Commerce:

April, May and June are usually the peak months for the awarding of road and street contracts; but juding by the numbe of bids asked, July will show a total exceeding either April, May or June of this year. There has been more or less delay in placing highway work under contract this year, so that August is likely to witness as great a volume of contracts awarded as in July.

The road and street contracts awarded during the first six months of the year were as follows:

Half year.	
1920	$233,000,000
1921	239,000,000
1922	271,000,000

This is exclusive of bridge contracts, and of course, it does not include highway work done by forces under the direct employment of cities, counties and states.

Bearing in mind that average contract prices are about 25 per cent below those of 1920, it will be seen that 1922 will be the record year for road and street work. Even so, the $700,000,000 worth of highway work that will be credited to the year 1922 is far below the needs of the public, if we may judge by the sales of motor cars and trucks. Moreover, the amount of capital that is being invested in street improvements is subnormal, and it never was adequate. We are apt to lose sight of this fact, because we see relatively large sums spent in country road improvement. The average municipality is poorly paved. There is need of organized effort to put city streets on a parity with country roads in respect to the character of the pavements.

City of 11,000 Begins $1,000,000 Paving Program.—Florence, S. C., a city of 11,000 population, has begun work on a $1,000,000 street construction program that involves 30 miles of new asphalt streets.

Federal Aid to Roads in Public-Land States

A statement showing the amount per mile and the percentage of the total cost that can be paid on Federal-aid road work in certain public-land States from the $50,000,000 recently authorized for the fiscal year beginning July 1, has been issued by the Bureau of Public Roads of the United States Department of Agriculture.

Fifty per cent of the cost, not to exceed $16,500 per mile, is the maximum participation in all States except those containing unappropriated public lands in excess of 5 per cent of all lands in the State. For these States the special provision is made that the Government may participate to the extent of 50 per cent plus a percentage ratio of the total estimated cost equal to one-half of the percentage which the area of the public land bears to the total area of the State. The maximum Federal aid of $16,500 per mile is increased by a like percentage.

This has been done to secure the construction of important trunk line highways through thinly settled regions.

The table is as follows:

State.	Percentage payable by United States.	Maximum Federal-aid payment per mile of highway $16,500 basis.
Arizona	61.11	$20,167
California	59.31	19,575
Colorado	56.12	18,521
Idaho	58.01	19,144
Montana	53.04	17,503
Nevada	87.22	28,784
New Mexico	61.50	20,207
Oregon	61.13	20,175
Utah	74.85	24,701
Wyoming	64.65	21,335

These are based on the area of unappropriated public land as reported by the Secretary of the Interior and may be changed on July 1, when new figures are reported.

Economic Survey of Roads in Tennessee Published

"Highway Economics and Highway Transport in Typical Counties of Tennessee," by Prof. N. W. Dougherty, has been issued as Bulletin No. 1 of the Engineering Experiment Station of the University of Tennessee. The bulletin is a report on a co-operative survey by the University of Tennessee, the Bureau of Public Roads of the United States Department of Agriculture, the Tennessee State Highway Department and county authorities, during the summer of 1921, in four counties of Tennessee.

The object of the survey was to secure information on highway economics of interest to highway officials in general and to lay before the people of particular counties a statement of the present condition and cost of their highways, maintenance costs and the probable cost of improving the system to meet present and future needs, as a basis for future development.

Existing systems of the counties were inspected and the roads classified according to type and condition and records of cost obtained. Maintenance methods and costs were also investigated. A number of traffic counts were made on roads of various degrees of importance and information as to farm values and production secured. From these data necessary improvements to meet the needs of present traffic and that of the near future were outlined and an estimate made of the necessary expenditure.

The bulletin does not give details of the data collected but gives gross figures to support the conclusions drawn.

The bulletin discusses factors governing selection of type of pavement, relation of traffic to highway expenditures and the necessity of planning so that all needs will be cared for in the most economical way.

Keeping in Touch With District Highway Offices by Radio.—A radio broadcasting station has been established in the office of Frank Page, State Highway Commissioner of North Carolina, and receiving stations in each of the nine district offices of the state highway department. It is stated that with this equipment the administrative forces of the Commission will be able to get in immediate touch with the construction and maintenance engineers throughout the State and thus effect a saving of several hundred dollars per month in telegraph tolls and in stenographers services.

Why a Contractor May Lose Money on a Highway Job

Thirty-seven reasons why a contractor may lose money on highway work were printed in a recent Weekly Letter of the Contractors' Association of Northern California. The notes, which were taken from a paper presented before the Associated General Contractors by H. R. Wilson, are as follows:

1. In general, careless estimating and failure to analyze and anticipate in their bids the many factors to be encountered.

2. Taking the engineer's estimates on work as final criteria of the costs of same and submitting bids below those estimates with the apparent conviction that the engineer computing said estimates possessed some occult powers of divination which made it impossible for bidders to lose money so long as their bids remained within hailing distance of those estimates.

3. Leaving the preparation of their bids to some material or bonding man who was interested in their efforts to secure a particular contract.

4. Applying cost data gleaned from handbooks and trade literature upon the subject and undue reliance on it.

5. Submitting prices merely made to beat the previous low bidders, evidently and alone in the child-like faith that the previous low bidders could have made no mistake, or submitting bids which are nothing more than an average of the bids submitted upon a number of other projects, apparently alike.

6. Failure to give the subject of bidding the time necessary for the completion of a thoughtful bid.

7. Failure to realize the many elements of risk and uncertainty which the specifications usually require the contractor to assume and which should properly be assumed by the state, and failure to cover these elements in their bids by a proper percentage of probable occurence.

8. Failure to take proper account of the hardships so frequently resulting from the elements of risk and uncertainty included in most highway contracts.

9. Failure to recognize the fact that, in normal times, a contract located close to large centers of population and production, cannot usually be prosecuted on as economical a wage scale as one comparatively removed from competition in this line.

10. Use, in bidding, of lowest quotations on aggregates without careful examination into the character, suitability, and possibilities for future rejection of the same, as well as the producer's ability to furnish the maximum amount of material when, and as required.

11. Failure to plan unloading and storage facilities so as to permit a producer of small capacity upon whom one may have to depend to make shipments evenly at all times, or to enable stocking of materials to cover strikes, embargoes and other contingencies.

12. Failure to study available labor supply and prices likely to prevail for same during the life of a contract.

13. Failure to study availability of cars and train movements involved with material shipments.

14. Failure to consider whether one will be able to perform a prospective contract with an old experienced organization or with a new organization to be assembled for the work in question.

15. Failure to properly consider probable duration of working season and the expense incident to carrying on organization through the winter, particularly where this expense results from inability to complete project in one season as may be contemplated when submitting bid.

16. Failure to recognize fact that existing sidings for delivery of material may prove inadequate for proper prosecution of work and protection of progress and to include expense for construction of additional sidings or extension of existing facilities.

17. Failure to consider suitability and volume of water supply and the charge for additional equipment which may be necessitated through failure at any time of an anticipated source of supply.

18. Failure to properly consider character of roads available for hauling and the result-transportation costs under all weather conditions.

19. Failure to investigate or consider, as far as practicable, character of engineers and inspectors to be dealt with.

20. Failure to charge off the amount of plant depreciation which may be experienced from a falling market, unsatisfactory machinery purchased or inability to complete work in anticipated time.

21. Failure to properly analyze and consider soil, and topographic conditions, right of way problems, and any structural obstacles along right of way in their relation to wet weather, progress, transportation and resulting costs.

22. Failure to provide for proper and economical sequences of operations and for the most satisfactory and economical equipment for executing work in hand.

23. Failure to charge on estimate for the cost of freight and hauling on many small items of supplies, insignificant in themselves individually, but amounting to a large sum in the aggregate.

24. Failure to investigate cost of supplies such as lumber, coal, feed, etc., also leases, rentals, freight on plant, camps, warehouses, plant, traveling expenses, losses on transportation of labor, legal expenses and many other items which might be mentioned in their relation to a particular contract.

25. Failure to recognize that costs used in compiling a bid may have been achieved under the direction of a more competent superintendent and a more efficient organization than you will be able to secure for the prospective project.

26. Failure to consider the existing condition and probable course of the markets during the life of a contract. This factor must always be balanced against cost figures procured from a contract already executed.

27. Failure to study all excavation involved in the field and to work out in advance of bidding an appropriate classification of material to be handled in grading, foundations, ditches, borrow pits, shoulders, dressing slopes, refilling rock breakage in cuts, etc. Almost any constructor can tell you what the total unit cost of excavation was on a particular job, but few can tell how many yards of each of the various classes of material were handled by a particular method and the resulting unit costs. Because of the difficulty and expense necessary to properly keep such costs we not only find constructors' records, but the actual technical literature in existence on this particular subject, very barren.

28. Failure to estimate even approximately on the amount of fence moving, sod, clearing, scarifying and other items which may be included in the excavation price.

29. Failure to approximate average length of haul or overhaul on excavation and borrow.

30. Failure to recognize that, on most road construction in cuts it is impracticable not to excavate a large portion of the shoulders and then replace same without payment for either operation.

31. Incurring heavy demurrage charges through failure to provide for orderly shipment and unloading of materials. (One highway constructor in the East was forced to pay several thousand dollars demurrage in a single season through accumulation of cars due to carelessness in design of unloading plant and ordering of shipments.)

32. Failure to allow an estimate for expense of stocking and rehandling materials and for waste in materials incident thereto.

33. Failure to properly figure average haul on materials for pavement, masonry and other items for the work as a whole.

34. Failure to figure cost of steel bars, pins and filler required for expansion joints.

35. Failure to figure shrinkage as between loose measure and solid measure in the construction of sub-base, broken stone base and other foundation courses.

36. Failure in bidding on masonry work to recognize the great variation in the unit costs of labor and other expenses as between bridges, walls and other heavy masonry and pipe head walls. Aside from bridge parapets, the construction of head walls will be found to be comparatively much more expensive than other masonry quantities not only in labor, but also in waste of material as well. (As an instance of this on a road project built in 1920 the cost of rubbing down head walls with labor at $4.50 per day, was found to be 30 cents per cubic yard of concrete placed in head walls.)

37. Failure to make proper charge for supplies required in connection with concrete masonry, tile underdrains and other miscellaneous items of contract work.

Progress of Tests of Bates Experimental Road, Illinois

The sixth traffic test of the Bates experimental road is now being run off by the Illinois Division of Highways, of which Clifford Older is chief highway engineer. The load now being applied is 8,000 lb. on each of the rear truck wheels and 1,930 lb. on each of the front wheels. As this load is the legal limit for Illinois, it is intended to make 10,000 applications so that a thorough test can be given all the remaining sections. It is probable that 5,000 applications will be made during the day and 5,000 at night. It is expected that this run will extend over six weeks' time, as the maintenance of the sections will undobutedly present a complicated problem.

The Bates experimental road, a full description of which appeared in the March 1, 1922, issue of Engineering and Contracting, consists of a series of full-sized sections of various types of pavement. These sections are being tested to destruction by actual truck traffic. A fleet of 16 trucks is utilized, each loaded so the total weight applied by each wheel will be the same at a given time. These trucks make regular trips up one side of the road and back on the other. Guide lines are painted on the surface of the pavement so that the application of the load to each section is always made at the same spot. In order that the drivers may keep their trucks on the required lines of travel, they are provided with sights on the radiators and on the windshields; by aligning these with the guide marks painted on the surface of the pavement, the accuracy of the path of travel is maintained.

The first traffic run was started on March 30, 1922, and the fifth run was completed on July 1. We are reprinting below the report on the last mentioned run issued July 8 by the Illinois Division of Highways, which with the accompanying illustration, summarizes the result of the tests up to the first of July:

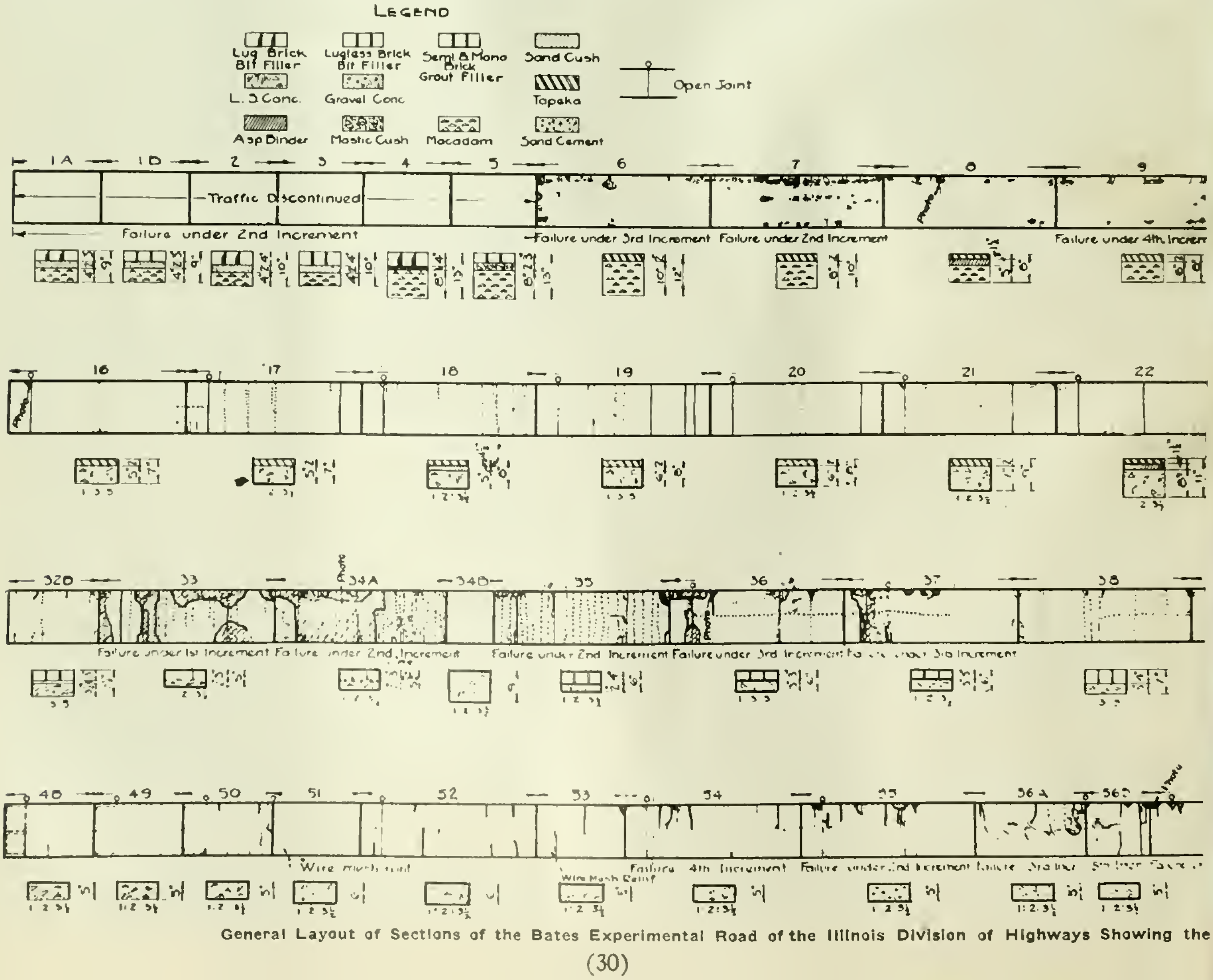
Though delayed to some extent by maintenance troubles, the run of the fifth increment of load on the Bates Road was completed in the morning of July 1st. As in three of the preceding runs, 3,000 applications of the load were made; 2,000 at days and 1,000 at nights. The load used in this run was 6,500 lb. on each of the rear wheels and 1,800 lb. on each of the front wheels. The same trucks were used as in all preceding runs, brick piled in the boxes and held in place by 2x4 lumber, making up the necessary load. The load as applied corresponded to 650 lb. per inch of nominal width of rear tire, and 360 lb. per inch of width of front tire.

Again a variation in time of application of loads was made in this run. The night traffic (1,000 applications) started off the test, with the day traffic (2,000 applications) completing the run. The path of traffic with this load was exactly the same as in the last run, the trucks traveling 2 ft. 6 in. in on the north side and directly on the edge of the south side of the pavements.

Due to the large number of failures in some of the lighter sections it was necessary to halt traffic at various times during this run and maintain the sections. At certain places the pavements were broken to such an extent that the trucks were unable to travel through them. The paving surfaces in these sections were entirely removed and were replaced by novaculite which when pounded down presents a comparatively smooth path of travel. In one section of monolithic brick it was necessary to use over two carloads of novaculite before traffic could be maintained with any degree of efficiency.

Up to July 1 the pavements have been subjected to the following loads:

Increment.	Rear wheel.	Front wheel.	Night application.	Day application.	Path of Travel.
1st	2,500	2,150	.....	1,000	Each edge of pavement.
2nd	3,500	2,150	1,033	2,167	627 day trips on edges; 1,540 day and 1,033 night trips. 2 ft. 6 in. from north side, on edge of south side.
3rd	4,500	2,000	1,000	2,000	2 ft. 6 in. from north side, on edge of south side.
4th	5,500	1,900	1,000	2,000	Same as 4,500 lb. load.
5th	6,500	1,800	1,000	2,000	Same as 4,500 lb. load.



General Layout of Sections of the Bates Experimental Road of the Illinois Division of Highways Showing the

Under the load of 6,500 lb. it was expected that most of the 5 in sections would show failures as this load applied 6 in. from the corner produces a stress of 600 lb., if the corners are considered as unsupported cantilevers. Failures were also expected in some of the 6 in. sections as a stress of 400 lb. is secured with this load applied at free corners.

The illustration of the general layout of the sections shows the development of breaks under the last increment of load. It is to be noticed that practically every one of the lighter sections have completely failed under the loads that have been applied to date. These loads are well under the legal load allowed in this State.

In regard to the failure in Section 44 it must be said that there is sufficient reason to believe that this failure might have been brought about by factors other than the load of 6,500 lb. This particular corner has been used during the summer and winter of 1921 for static loading tests and during this time was stressed to a considerable degree above its fatigue endurance limit.

Following is a description of the behavior of the different sections:

Bituminous Filled Brick on Macadam.

Sections 1A-5 inclusive. Continuous and complete failure under second increment. Traffic discontinued.

Section 6. This section failed under the third increment.

Section 7. This section failed under the second increment.

Section 8. 7 additional points of failure and 6 points of progressive failure. This section apparently reached its maximum carrying capacity under this increment. After 1,000 applications of load about 800 gal. of water were poured into short trenches at three points along the south edge of the pavement. Before traffic was resumed the trenches were filled with novaculite and tamped. Failures occurred at all three points. The behavior of this pavement after using the water indicates that this section in all probability would have failed under previous increments if loading had occurred during spring conditions when the subgrade is highly saturated.

Section 9. Continuous and complete failure under fourth increment.

Section 10. Continuous and complete failure under first increment.

Section 11. Continuous and complete failure under second increment.

Asphaltic Concrete on Portland Cement Concrete Base.

Section 12A. 3 additional corner failures, progressive breaking of adjacent pavement at previously reported broken corner, and 2 additional cracks through curb and base not in vicinity of transverse cracks or joints. This section considered failure under fourth increment.

Section 12B. No additional failures.

Asphalt Concrete on Portland Cement Concrete Base.

Section 13. 1 additional crack in curb and base not in vicinity of transverse crack or joint.

Section 14. 1 additional corner failure and progressive breaking at previously broken corner. This section considered failure under fourth increment.

Section 15. 1 additional corner failure. 2 cracks in curb and base in vicinity of previously broken corner, possibly progressive breaking. This section considered failure under fourth increment.

Section 16. 1 decisive corner failure with progressive breaking of adjacent pavement.

Section 17. No additional failures.

Sections 18 and 19. No additional failures.

Section 20. No apparent failures.

Section 21. 1 additional corner failure. Not decisive. Probably caused by impact from small initial corner broken in cutting joint.

Section 22. No apparent failures.

Bituminous Filled Brick on Portland Cement Concrete Base.

Sections 23-25 inclusive. No additional failures.

Section 26A. 1 progressive break at previously reported corner.

Section 26B 1 crack in curb and base not in vicinity of transverse crack or joint.

Section 27. Progressive breaking at two previously broken adjacent corners. This section considered failure under second increment.

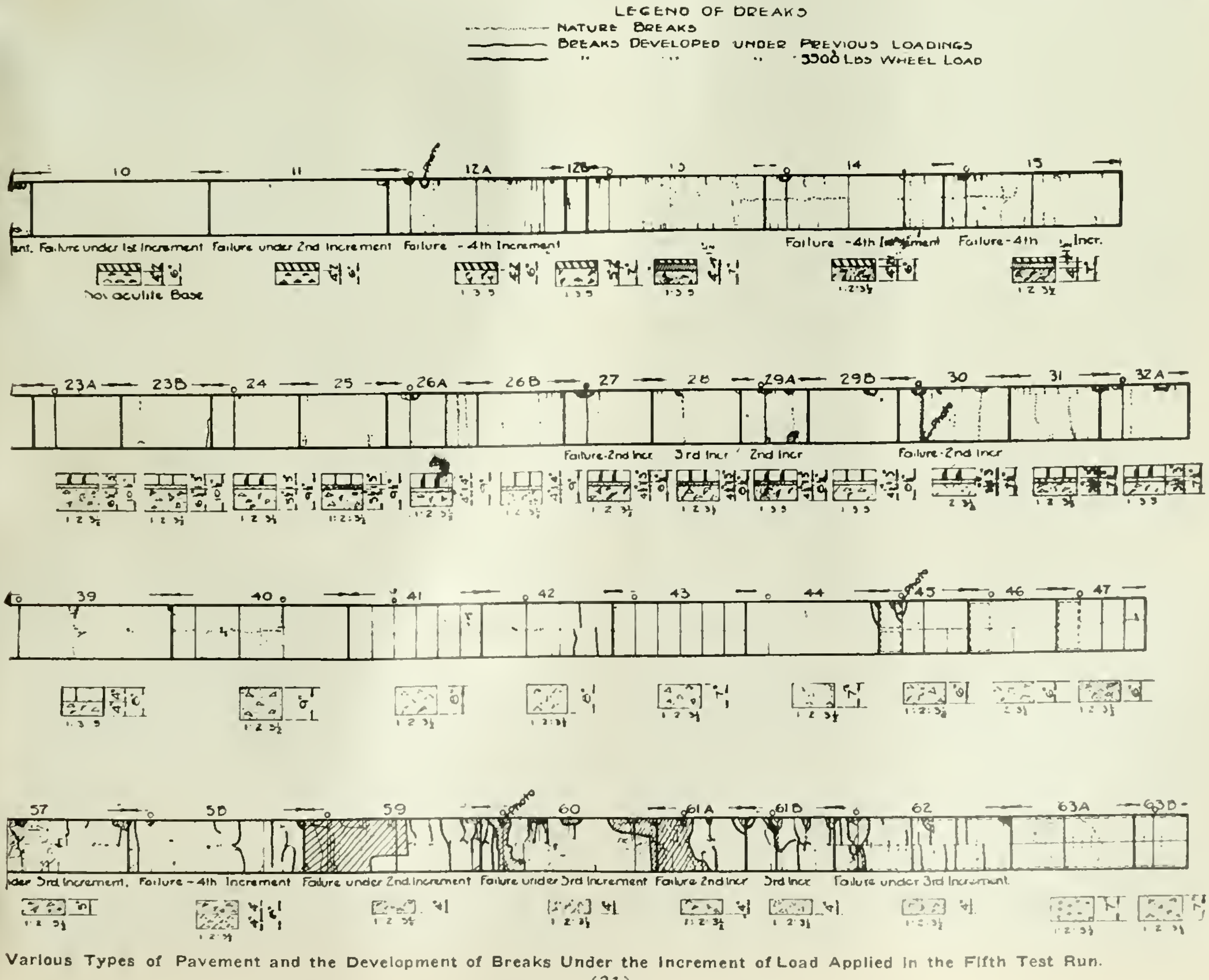
Section 28. Progressive breaking at previously reported corner. The section considered failure under third increment.

Section 29A. Crushing of base in outer wheel track on north side within repaired blowup. This section considered failure under second increment.

Section 29B. 2 decisive corner failures.

Bituminous Filled Brick on Portland Cement Concrete Base.

Section 30. 3 additional corner failures with progressive break-



Various Types of Pavement and the Development of Breaks Under the Increment of Load Applied in the Fifth Test Run.

ing at one. Rapid destruction across entire width of pavement at cut joint This section considered failure under second increment.

Section 31. Progressive breaking at previously broken corner.

Section 32A Progressive breaking at one previously reported corner and failure at two corners broken before introduction of traffic.

Section 32B. 1 additional corner failure. Apparently decisive.

Monolithic and Semi-Monolithic Break.

Section 33 This section failed under first increment.

Section 34A and 35. These sections failed under second increment.

Section 36. This section failed under the third increment.

Section 37. This section considered as failure under third increment.

Section 38. 2 additional corner failures.

Section 39. 1 additional corner surface failure.

Portland Cement Concrete.

Section 40. 2 short cracks within section.

Section 41. 3 short cracks within section.

Section 42. 3 cracks from center of pavement to edge.

Section 43 No apparent failures.

Section 44. 1 corner break with a progressive failure. The failure of this corner is believed to be due to the fact that it had been stressed many times, for experimental purposes, beyond its fatigue endurance limit.

Section 45. 2 corner failures with progressive failure at one. Decisive.

Section 46. No apparent failures.

Section 47. 1 short crack within section.

Sections 48 and 49. No apparent failures.

Portland Cement Concrete.

Section 50. 1 interior corner failure and 2 cracks from quarter point to edge.

Section 51. No apparent failures.

Section 52 Extension of several old cracks to edge of pavement.

Section 53. 1 corner failure adjacent to previously broken corner in adjoining section. Not decisive. 1 transverse crack from center to edge.

Section 54. 4 additional cracks from center of pavement to edge and 1 from quarter point to edge. This section considered as failure under fourth increment.

Section 55. This section failed under the second increment.

Section 56A. This section failed under the third increment.

Section 56B. 3 additional corner failures with progressive failure at one and several cracks within section. This section considered as failure under this increment.

Section 57. This section failed decisively under third increment of load.

Section 58. 2 additional distinct corner failures, progressive failures at previously reported corner, and several cracks within section. This section considered as failure under fourth increment.

Section 59. This section failed under the second increment.

Section 60. This section failed under the third increment.

Section 61A. This section failed under the second increment.

Section 61B. This section failed under the third increment.

Section 62. This section failed under the third increment.

Section 63A. 1 transverse crack entire width of pavement.

Section 63B. No apparent failures.

Road Dragging in Canada

Experience in the maintenance of Provincial Highways, and certain county road systems, according to the recently issued annual report of the Department of Public Highways of the Province of Ontario, has demonstrated fully that the dragging of earth and gravel roads is of the greatest advantage. Says the report: "Were townships to establish adequate organization for dragging their gravel roads, a wonderful improvement would result in the road system of the Province. A steel drag with three blades, known as a 'road-plane' is extremely effective in keeping a gravel road in the best possible condition. A light coating of moderately fine gravel should be added annually, if possible, to keep a floating surface over the gravel. Without this floating layer of gravel, an inch or so in depth, there is nothing for the plane to work with, to keep depressions and holes filled. Care must also be taken not to cover the gravel with earth or clay by drawing the latter from the edges of the road with the plane. Over half the roads of the Province are gravelled. Systematic dragging of these roads would work a revolution in road conditions such as no other method would produce. Dragging can also be extended to earth roads with splendid results. But this plan of maintenance is not applicable to stone roads unless they are first covered with a light layer of suitable clean gravel or very fine crushed stone."

Method of Presenting Thoroughfare Problem to Voters

The importance of setting forth clearly and very briefly to the voters of a city the reason for the selection of a certain group of streets for thoroughfares, cannot be overestimated. Unless the voters are thoroughly convinced that the lines selected are logical, there is little chance that the officials will meet with success in carrying these lines forward to execution. An excellent method of presenting the thoroughfare problem in a way to catch and hold the attention of the "man in the street," is given in a recent report prepared by Arthur A. Shurtleff, landscape architect, Boston, Mass., for the Planning Board of Newton, Mass. Mr. Shurtleff described this method in a recent discussion before the Boston Society of Civil Engineers. The notes following are taken from his discussion.

The readers' attention was sought by the use of a series of thoroughfare maps and plans, and by a series of corresponding brief paragraphs printed in large type with attractive headings. This material was arranged on large sheets.

Evidently the "man in the street" is more incredulous regarding the thoroughfare system for an exceedingly irregular system of streets than concerning one which follows a rigid gridiron layout. For that reason, the first plan shown in the Newton Report illustrates the present street system and over it is written in large letters, "The Plan of Newton's present Street System looks confused."

The reader is then reminded that the apparent confusion of the plan arises in part from the irregularity of the ground which makes long continuous straight streets impractical, and from the fact that Newton, like most other communities, grew by accretion without adherence to any rational plan. The suggestion was then made that an approach to a rational system of highways might be discovered by the method of anaylsis which is illustrated in the diagrams. The first of these diagrams is evolved by combining the tangle of streets to reveal only those which lead continuously across the city from North to South. This diagram is accompanied with a large heading reading, "Only Six Through Streets Now Cross the City North and South." The readers' attention is then called to the fact that this system of thoroughfares is inadequate as the streeets lie nearly a mile apart and that intermediate through streets could be created if the fragments of intermediate streets were united.

The next diagram shows the method of uniting these fragments to secure the thoroughfares described, and a careful statement is given of the distance separating these thoroughfares with a cross reference to the spacing of similar thoroughfares in well known so-called "Garden Cities" of the country.

An analysis of the existing through streets crossing the City from East to West is then shown in a diagram. In this case, the combing operations reveal only East-West through streets and is described with a heading, "Only Seven Through Streets Now Cross Newton East and West."

Having held the readers' attention more or less successfully to this point, it is a simple step to indicate, by methods noted above, the feasibility of uniting street fragments to create many more through streets in this direction. This operation of piecing together is shown on a diagram which is entitled, "Twelve Additional East and West Through Streets can be Found."

Obviously the "man in the street" who is in a critical frame of mind, wishes to be assured still further of the wisdom of these thoroughfares by reference to a more detailed map giving the names of the fragments to be united, and recalling to his mind the topography involved. These facts are set forth on a large plan nearly a yard square at the end of the report on which all these lines are combined.

The report also provides, for the use of those who wish to pursue the subject further, a schedule of street connections and street widths. Diagrams are also given showing the feasibility of accommodating modern traffic in streets of widely different capacity.

Thus far, the Newton report has met with unusual success as it has been widely read by the "man in the street."

Highway Construction in Pennsylvania.—The State Highway Department of Pennsylvania up to July 21, during the 1922 construction season has put down approximately 150 miles of durable highway.

How a County Maintains Its Gravel Roads

Methods in Story County, Iowa, Described in Paper at Annual Conference of Iowa Roads Officials

By SAM STEIGERWALT,
County Engineer, Nevada, Ia.

Our primary system is composed of one road straight across the central part of the county east and west, and one near each side of the county running north and south, totaling 64 miles, divided into two patrol districts or patrol headquarters.

Maintenance of Primary Roads.—Two men located at Ames with one Quad truck, one Ford truck, one Cletrac tractor, one 8-ft. Adams grader, with a 12-ft. blade, two 12-ft. drags, and several smaller drags, take care of 24 miles. They do all of the dragging on the 9½ miles between Ames and the Polk County line, and all necessary patrol work other than dragging on the other 14½ miles. We aim to keep teamdraggers on about one-half of the primary road, as these can be hired by the mile and work only when dragging is necessary, while if we kept patrol men enough to do all of the dragging within 24 hours there would not be work enough to keep them busy between draggings, and the total investment in equipment would be more than double.

At Nevada we have four men, a foreman, a mechanic, a grader man and a truck driver. They are all truck drivers when necessary and do their special work when that kind of work comes up. Equipment at Nevada consists of one Nash Quad, two F. W. D.'s, one Packard, one Ford, one 12-ft. Adams Reclamation ditcher, one 20:35 Twin City tractor, three 12-ft. drags and several 10-ft. drags.

Twenty-three miles are kept dragged by the Nevada squad, and patrol work other than dragging is done on the balance of the district. This squad also does most of the small repairs on wood bridges over the county, builds inlets and hauls tile and fills tile ditches on the county road system, besides doing most of the repairs on all of the county trucks, tractors, blade graders, drags, etc.

Truck Hauled Drags.—All of the large trucks are equipped with cabs or storm aprons, and as soon as it starts to rain, at least three trucks are sent out to drag the center of the road to keep the ruts and pot holes from forming and holding water to soak up the roadbed.

For this kind of dragging we are using one Engle 10-ft. drag behind each truck. These drags are long enough to cover the center of the road in good shape and will let the traffic by on either side and do not extend out so far on the other side as to hook into the loose heavy gravel and earth on the shoulder. The trucks travel along about 4 or 5 miles per hour on intermediate speed and do a real job in keeping the roads in shape during a continued rainy spell, when no other equipment could be out in the weather.

As soon the the rain stops two trucks are started out together with two 12-ft. drags or a blade grader and one 12-ft. drag. They cover practically the whole road and keep far enough apart to let the traffic work around one on the right and around the other on the left.

The drags are adjusted so as to drag either in or out, as the road requires. These two trucks will go out from 12 to 14 miles and back in a day, and on the return trip the road, which is now getting almost dry, gets a double dragging.

The next day, if the weather continues cloudy, and the road stays damp, one truck makes another trip with a 12-ft. drag and smooths up the soft places.

During dry weather, just enough dragging is done to keep the traffic spread out over the road surface and prevent ruts from forming. Taking the entire season through, about one-third of the patrolmen's time is taken up dragging.

Our primary roads are all well drained, approximately 500,000 ft. having been placed on the 64 miles.

At present 43 miles have been graveled, and during 1922 14 miles will be given the first coat and 9 miles a maintenance coat.

The patrolmen have hauled about 400,000 ft. of the tile placed; they have filled all of the tile ditch, have spread and worked practically all of the gravel placed, and two men, with the 20:35 Twin City tractor and a 12-ft. Adams grader, working about two days a week during the summer months, have kept the earth roads shouldered up and flat on top, just ahead of our graveling operations.

Tractor Grading.—Gang maintenance on primary road consists of hauling maintenance gravel, which is all done by contract, and tractor grading, which is also done on contract by the hour. In the spring of 1921 the county purchased a 12-ft. Adams Road King with back-sloper, and contracted with H. R. Hilleman, of Marshalltown, to furnish a new 40:60 Twin City tractor and two men to run the outfit at $6.50 per hour for actual time put in. This work consisted of following up the completed drainage and widening the crown out to 28 ft. and building up square shoulders and a flat top preparatory to graveling. Later in the season we widened out 9½ miles of graveled road and scarified the surface and built up the shoulders preparatory to placing a maintenance coat of gravel. This season we have 16 miles of good gravel road that has too much crown, and we are going to widen out and build up the shoulders without scarifying, as we do not expect to place any maintenance gravel on this section this season.

Cost of Maintenance.—During 1921 this outfit covered 37 miles at a cost of about $200 per mile.

All of the team dragmen are supplied with 10-ft. Engle drags and are paid 40 ct. per mile traveled.

The patrolmen are paid 40 to 50 cts. per hour for actual time worked and will average about $1,000 per year per man.

During 1921 Story County paid out for maintenance on Primary Roads the following amounts:

For patrol maintenance	$16,232.14
For gang maintenance	30,482.02
For equipment and tools	5,954.68
Making a total of	$52,668.84
Making an average per mile of	$ 819.74

The above amount includes tractor grading on 26 miles, maintenance gravel on 26 miles and a great deal of clearing and grubbing, excavating for inlets, smoothing up tile ditch filling, shouldering up for graveling, and other work which really was construction work in that when once done it is done for a long time.

Maintenance of County Road.—The 131 miles of county road are divided into 7 districts of 14 to 22 miles each, with one patrolman with team in each district. He is equipped with a small blade grader, slip, plow and dump boards for his wagon, and receives 60 cts. per hour for actual time put in.

These team patrols do very little dragging, as practically the entire county system is covered by farmer dragmen, with teams or small tractors.

They haul gravel for patching short stretches of road, keep the loose gravel worked in, and the grass and weeds scraped from the outside edge of the shoulder, keep the culverts and tile inlets clear of rubbish, and other odd jobs found necessary.

The county maintains two large tractor and grader outfits for shaping up the shoulders of the county road system. This work cost approximately $200 per mile during 1921.

The total cost of maintenance on the county road system during 1921 was $34,388.16, or approximately $262.50 per mile, of which $147.43 per mile was for patrol maintenance, and the balance for gang maintenance.

We are at present trying out a home-made steel drag, also a large size Iowa Maintainer, and I believe that both of them are going to show results as to efficiency and economy of operation.

Road Building Contracts in Canada.—Reports to Highways Information Service, New York, from the various Canadian provinces for June, 1922, show contracts for new roads and streets let during that month to the value of $3,774,200. The total number of contracts let was 72. New projects reported under consideration numbered 146 and were to cost $4,697,600. The value of the new construction contracted for during June in each province was as follows: Ontario, $1,664,900; Quebec, $822,000; New Brunswick, $151,900; Nova Scotia, $115,000; British Columbia, $383,300; Alberta, $16,500; Saskatchewan, $26,000; Manitoba, $47,400.

To Prevent "Scour" of Green Concrete.—Scouring of green concrete by water when curing by the ponding method was prevented by a Western contractor by the simple expedient of wiring a gunny sack to the nozzle of the hose and discharging the water through the sack.

Progress of Highway Research

A Paper Presented June 21, Before the American Society of Civil Engineers

By DR. W. K. HATT,
Director Advisory Board on Highway Research Division, National Research Council.

At the meeting of the American Society of Civil Engineers at Ashville, N. C., some 20 years ago, the writer outlined the contemplated program of the timber investigations of the Forest Service, U. S. Department of Agriculture. Since that time these researches into the properties of wood, and the technology of its preparation for the market, first at several scattered laboratories, and then more effectively at the Forest Products Laboratory at Madison, Wis., have securely founded this branch of science. The necessary condition of success was obtained, when the problem was approached by a coordinated staff of engineers, chemists, physicists and histologists.

It appears that an early solution to the more complicated, and, from the standpoint of national well-being, more grave problems of highway transport, will be reached only in so far as the highway engineer, the highway official, the vehicle designer and manufacturer, and the organizer and operator of highway transport systems, can in conference come to an understanding of the aims of each other, and to a recognition of the public service to which they are called. To this group should be added also steam and electric railway operators, so that highway transport may find its appropriate function in a coordinated structure of national transportation.

Happily the highway engineers and the motor vehicle manufacturers are now seeking a common viewpoint, and are in the way of finding a common purpose from which to reach sound policies in the financing, building and use of highways. May we not hope for the contribution of those representing other systems of transportation to a scientific study of these questions.

Need for Scientific Research.—I submit that we must move from the field of opinionated discussion into the field of judgment, through data secured by scientific research. Many more traffic, or rather highway transport surveys, such as those under way in Massachusetts and Connecticut, are needed for a visualization of this activity, and for a prediction of the future needs for highways and terminals for its accommodation.

There is new wine in old skins. We have inherited many ideas from a use of highways, not far removed in time but different in nature and so very small compared to that of the present time. The recognition by engineers and economists of the essentially different roles played in highway financing by the several elements of the highway right-of-way, grading, structure and surfacing—this distinction so obvious when presented, is new to many intelligent minds. That the highway is an investment, and that the measure of accomplishment is not the building of mileage, but the resulting reduction in the costs of transportation, is a conception that is needed to clarify discussion. Almost everyone is a first-hand observer of highways, and there is here a splendid opportunity for the education of an interested public.

It is not my purpose today to discuss national problems of highway transport. The time will be most profitably used in illustrating typical resarches which operate not only in the fields of materials of construction, so long and patiently occupied hitherto, but in traffic surveys, measurements of operating costs, and tractive resistance. The action of the vehicle on the road and the design of the surface and base to carry these loads over determined subgrades.

Confusion of Organizations.—However, I must first comment upon the confused assemblage of organizations and committees active in the field of highway transport research and regulation. One aspect of science is a simplification and economy of thought, and one aspect of engineering is economy of action. In highway matters, as in general engineering, a service would be rendered by some organization which would analyze the functions of committees and inquire into the duplication of function and the overlapping of the field of effort. A list of 24 organizations interested in the technical aspect of highways will serve to indicate the potential energy of workers prepared by experience and motivated by desire.

Some consideration of the activities of committees of technical organizations in general may disclose a too heavy assignment of one individual to numerous committees. We should distinguish between those committees that pass judgment upon prepared evidence, and those that are expected industriously to gather and to formulate evidence.

Some of our highway committee problems are so important that organizations, governmental or industrial, would be justified in assigning an individual for full service to the work of his committee. How can a man who has full responsibilities to discharge and duties to perform at home, give adequate attention to committee work? And so a stellar committee roster may be imposing potentially, but a little kinetic energy.

Coordination of Research.—The Advisory Board on Highway Research, Division of Engineering, National Research Council, is organized to prepare a comprehensive national program for highway research; to assist existing organizations to coordinate their activities therein; and to collect and distribute information of completed and current research. This is not a directing, but a service organization, devoted to the interest of the individual reasearcher who instinctively resents interference from overhead desk men, and properly guards with care the products of his zealous research. Services that can be rendered the individual researcher are in soliciting support for his projects, in putting him in touch with his fellow workers through a Census of Research, and in illuminating a particular field with side lights from allied fields in which a project has its setting. The taxpayer will also benefit through a coordinated research activity on problems selected from comprehensive program with reference to the applicability to present day problems.

Examples:

Research on Tractive Resistance.—Highway researches in the field of economics of operation are connected under Committee No. 1 on the Economic Theory of Highway Improvement, Professor T. R. Agg, Chairman. In New England the tractive resistance of automobiles and trucks is being measured on several types of roads at speeds up to 30 miles per hour. The vehicles are tested for internal absorption of energy at the Yale labortory by Professor E. H. Lockwood, and the gross tractive resistance determined on the roads by Major Mark L. Ireland, Q. M. C., who is stationed at the Massachusetts Institute of Technology. Cooperating in this work are:

Bureau of Public Roads, U. S. Department of Agriculture, Committee on Economic Theory of Highway Improvement, National Research Council, Connecticut Highway Commission, Department of Public Works, Commonwealth of Mass., Harvard University, Massachusetts Institute of Technology, Society of Automotive Engineers, United States Army Q. M. C. Department, Yale University.

The investigation includes the effect upon tractive resistance of the temperature of the differential of the vehicle, and of various types of tires. Of course the gross tractive resistance is composed of several elements, such as engine, gearing, inelastic resistance of body, tire, windage, road surface, which distinguishes rolling, impact and displacement resistance. Account must be taken of the absorption and giving out of energy in the rotating parts, in accelerating or retarding speed. The technique of these measurements is not settled. The measuring instruments may be an accelerometer used in coasting tests, or a dynamometer, in towing tests each of which has its peculiar advantages. The first task is to determine the best instrument to measure the several elements into which the problem is analyzed. The Bureau of Standards has assembled appartus at a remarkable degree of completeness and perfection, which automatically records the measurements of some fourteen elements of car performance in road tests.

Professor L. E. Conrad, at Manhattan, Kansas, is conducting a parallel investigation of the resistance of the air to the passage of vehicles.

Study of Economic Grades.—At the University of Michigan Professor Lay in a study of economic grades has towed four Packard trucks over gravel and concrete roads, after he had determined their characteristics in the laboratory. The gravel roads varied in condition from wind-swept hard surfaces to a loose gravel surface. The concrete road varied from a very smooth finish to a more or less wavy condition. The gasoline consumption was also reported. The trucks were 5-ton with 3-ton pay load, and were run at a standard engine speed of 1,000 R. P. M., the gears being shifted to meet road conditions. Professor Lay finds that for these trucks, the tractive resistance, including rolling resistance, tire resistance and windage, varied from 40 to 44 lbs. per ton on the gravel roads, and from 22 to 26 lbs. per ton on the concrete roads, all at a speed of 10 miles per hour. Professor Lay's report, shortly to be published, is a notable contribution.

Economics of Highway Location and Operation.—At Ames, Iowa, Professor T. R. Agg has been investigating for a long time the economics of highway location and operation, especially with a view to determining economic grades, and his report is expected to be published by January, 1923.

The end in view is a sound economic theory of highway location and improvement.

Now, each of these investigations forms part of a whole. The individual researches profit by intercommunication, and in the end the entire results are more likely to be useful in the formation of principles by a coordinating service.

Experimental and Test Roads.—Again, in the field of design we may instance the experimental road at Pittsburg, Calif., and the Bates test road near Springfield, Ill., investigations of Mr. Goldbeck, of the Bureau of Roads, and the service test roads of Byberry, Pa., Lancaster, Pa., Casper, Wyoming, Alexandria County, Va., Wilmington, Del., and Milwaukee, Wis., all of which are directed to the same end and will yield a body of coordinated data flowing through the channel of the Committee on Design, and will place the mechanics of slab design on a scientific foundation.

Again, in the field of highway transport, the pioneer transport surveys on the Connecticut roads, inaugurated by Commissioner Charles J. Bennett, have crystallized formerly vague discussions, and have stimulated further work. The examinations by Dean A. N. Johnson of the University of Maryland, by Professor N. W. Dougherty, of the University of Tennessee, by Professor T. R. Agg in Iowa, by the Bureau of Public Roads in California, and less complete traffic counts in scores of instances—all of these need to be reported and examined for fundamental laws of traffic by a committee on traffic analysis.

A useful and money saving activity is in the Research Information Service of the Advisory Board, by which an individual state is informed of the findings from investigations in another state. Cases can be cited in which one state has been saved the delay and cost of an investigation relating to the use of materials, when informed of the completed investigations available from the work of another state.

430 Individual Highway Research Projects Underway.—The recent tabulation of the incomplete returns of the Highway Research Census of the Advisory Board indicates not only a large activity in this field in the 430 projects, but the possibilities of economy in time and money and the avoidance of unnecessary duplication.

NUMBER OF INDIVIDUAL RESEARCH PROJECTS IN HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT.

	Economics.	Operation.	Design (road).	Construction.	Materials.	Total.
Colleges and universities ...	17	3	47	12	127	206
Industrial	1	1	3	0	19	24
Municipalities	5	1	6	1	18	31
State highway departments.	13	2	25	8	101	149
State geologists	0	0	3	0	17	20
Total	36	7	84	21	282	430

It must be said, however, that duplication is not necessarily an evil; indeed it is useful in fundamental matters, as in the case of the investigation of fatigue of concrete. The parallel investigation at Springfield, Illinois, Purdue University and the University of Maryland, with different methods of attack, will more certainly lead to the truth. However, in these cases each will profit by communication with the other.

Mr. H. S. Mattimore, Engineer of Tests, State Highway Department, Harrisburg, Penna., is Chairman of the Committee of the Advisory Board on the Character and Use of Road Materials, also Chairman of the Committee of Tests and Investigations of the American Association of State Highway Officials. The latter committee is divided into sub-committees, each representing a region of the United States. Mr. Mattimore is furnished by the Advisory Board with an administrative assistant, and this combined attack on problems relating to the materials of construction represents a well organized committee activity.

These few instances will serve to demonstrate the value of the services of the Advisory Board in tieing together individual researches.

Granite Block Pavement Reconstruction and Asphalt Resurfacing

Recut Block and Heater Methods as Used in Brooklyn, N. Y., Described in Paper Presented at City Paving Conference, Philadelphia

By JACOB SCHMITT.

Granite Pavement Reconstruction.—In repaving a granite paved street the old material, where discarded, has but little salvage value to the community, because of the uncertain market for second-hand paving blocks. Contractors can afford to make but little allowance for such blocks and in consequence the community bears in full the value of the new blocks required. Why, therefore, should not the market for the old blocks be made on the job?

The blocks on many streets requiring reconstruction are of the old type, large size, 10 to 14 in. long, 3½ to 5 in. wide, and 7 to 8 in. deep. The size in use today is 8 to 12 in. long, 3½ to 4½ in. wide and 5 in. deep. The cubical contents of the old type block is practically double that of the newer type, so that two blocks can be produced from one. This is therefore done by splitting the old block through its center and redressing the resultant two blocks. The heart of the old block becomes the head of the new. In many cases it is not possible to obtain two blocks from one, owing to defects in the old stone, but the percentage of blocks suitable to produce two recut blocks is generally sufficient to overcome the loss in recutting and rejects. Experience has proven that the gain and loss practically balance. As a rule, there is a small surplus of blocks and in only a few cases has there been a deficiency. The only difference made in the size of block from current specifications (Brooklyn) for improved granite block is that the minimum length of block allowed is 6 in., as against 8 for new blocks, with a minimum width of 3¼ in. as against 3½.

Specifications for Recut Blocks.—These blocks are laid to the same specification requirements as for new blocks, with ½ in. maximum joints and 1 in. cushion, and bituminous or grout joint filler. The concrete foundation is built up by a full 3 in., the difference between the old 7½-in. block on 1½-in. cushion and the recut 5-in. block on 1-in. cushion. The following is an extract from specifications for this class of work:

"When the use of blocks recut from old granite blocks is permitted under the contract, such blocks shall comply with the specifications for quality as required for new blocks, and be of the following dimensions: not less than 6 nor more than 10 in. long on top; not less than 3¼ nor more than 4½ in. wide on top, and not less than 4¾ nor more than 5¼ in. deep. The recut block shall be dressed in the manner specified for new blocks; the sides and ends shall be sufficiently smooth to permit of the blocks being laid with joints not exceeding ½ in. in width at the top and for 1 in. downward therefrom, and not exceeding 1 in. at any other part of the joint. The blocks shall be cut so that the face will be approximately rectangular in shape. The top surface of the block shall be cut so that there will be no depression measuring more than ⅜ in. from a straight edge laid in any direction on the top and parallel with the general surface thereof."

Of this type of reconstructed pavement there had been laid in Brooklyn, N. Y., approximately 4,000 sq. yd. in 1919, 11,000 sq. yd. in 1920, 48,000 sq. yd. in 1921, with 62,000 sq. yd. (fall of 1921) now in progress or under contract.

Cost of Recutting Blocks.—The recutting of the blocks costs about \$30 per thousand, against a price on the work for new blocks of \$130. This difference is partially counterbalanced by the average size of the blocks, which run about 40 to the square yard, against 28 for new blocks. In September, 1921, bids were taken for both new and recut granite pavements, the new being priced at \$5.25 per square yard for pavement only, as against \$2.77 for recut blocks.

The results obtained have been entirely satisfactory and the saving in cost substantial. While old pavements may be so worn as to be useless for recutting, the method offers a practical solution of the problem of salvaging granite pavements which are worn but not worn out.

Asphalt Resurfacing.—The Borough of Brooklyn, N. Y., with its 11,000,000 sq. yd. of asphalt pavement, has experienced the difficulty of keeping such pavements in repair to a greater extent than most municipalities. The older pavements were laid without the careful attention to formula now given, with the result that much creeping and pushing of these pavements occurs under modern heavy traffic. Though far from worn out, their surface may be distinctly irregular and wavy. The asphalt may have in it many years of life, but be in such condition as to surface that a general overhauling is necessary. This is accomplished by the heater method of resurfacing.

Heater Method of Resurfacing.—The surface of the pavement is heated to a temperature such that about ½ in. of its surface is softened and can be scraped off. A layer of new asphalt surface mixture is spread upon the heated surface and rolled and finished in the same manner as surface otherwise laid If properly applied, this method produces an excellent bond. Many test cuts have indicated perfect adhesion of the new asphalt to the old, and the maintenance costs on resurfaced streets compare favorably with new full depth pavements. The heater used is designed to soften the pavement by hot air blast, the flame not being permitted to impinge on the pavement surface. The new layer is laid to an average thickness of 1 in. In preparation of the work before applying the heater, all excessive waves or hummocks are removed by cutting down to the foundation. The asphalt used is similar in formula to that employed on heavy traffic streets, its composition being as follows:

Passing 8-mesh sieve, retained by 10-mesh sieve	0% to 5%
Passing 8-mesh sieve, retained by 10-mesh sieve	25% to 45%
Passing 40-mesh sieve, retained by 80-mesh sieve	20% to 55%
Passing 80-mesh sieve, retained by 200-mesh sieve	10% to 30%
Passing 200-mesh sieve	13% to 20%

Bitumen, 9.5% to 12.5%.
Penetration of A. C., 35 to 45.

Should the old material be of doubtful stability, the use of the surfacing of stiff mixture serves as a protective coat and minimizes the creeping of the pavement.

This method has been used with success on streets of moderately heavy traffic, but its field lies chiefly in the improvement of pavements subjected to average traffic of residential sections and secondary arteries.

Specifications for Heater Method.—The following extracts from specification for such work are submitted:

"The repaving or resurfacing of the asphalt shall be done by process or method of heating and removing the surface of the old pavement by means of a properly constructed surface heater. The essential feature of this heater shall be that no flame comes directly in touch with the surface to be heated or softened. Its general construction shall be such as will admit of heated air being blown upon the surface of the old pavement to be removed, thereby heating and softening it so that all inert, disintegrated, worthless and uneven or irregular surface material can be easily removed by means of hoes, rakes, or other appliances.

"The contractor shall use proper guards to prevent the heat from cracking or injuring the curb, headers, or other structures along the line of the work. He shall prevent heat emitted from the stack from injuring trees or shrubs.

"Where excessive waves or hummocks exist, along headers and around manholes or wear holes, the contractor will be required to remove the old material by cutting to the foundation, where directed by the engineer, and replacing it entirely with new material.

"The surface of the old material must be clean, soft and hot at the time that new material is laid thereon. Should the surface become chilled, hardened, or dirty, it must be reheated and again cleaned before new material is applied.

"After the surface of the old material has been properly prepared, a coating of new material shall be laid thereon to such a thickness as to give when rolled, a layer of new material over the old not less than ¾ of an inch in thickness, and averaging as nearly as possible 1 in. in depth, after rolling."

Yardage and Cost.—In the Borough of Brooklyn 50,000 to 100,000 sq. yd. per year of heater resurfacing has been carried out for some years past with entirely satisfactory results.

The price in September, 1921, was $1.09 per cubic foot of wearing surface mixture or $1.58 per square yard. This compared with a price for asphalt only laid on the old foundation of $2.25, including removal of the old pavement. In September, 1920, the price was $1.43 per cubic foot or $2.03 per square yard, comparing with a price of $3.65 for specification asphalt. The price of resurfacing, therefore, ranges from 60 to 70 per cent of new asphalt, exclusive each of foundation.

This method is believed to be the most practical for salvaging the useful part of an old asphalt pavement. The material requiring handling is reduced to a minimum; the work is performed expeditiously and with the least possible inconvenience to residents on the street. Various methods of re-employing old asphalt in the preparation of a new mixture have been tried with varying success. The heater method, however, has been successfully used for years, and while the saving effected is less than in the case of the recutting of granite blocks, it is substantial and is supplemented by the comfort to residents in having a repavement started and finished the same day.

International Road Congress to Meet in Spain

The Fourth International Road Congress will be held next year in Seville, Spain. The congress will open in the beginning of May, 1923, and it will last six days. It is promoted by the Permanent International Association of Road Congresses formed in Paris in 1908 at the time of the 1st Congress.

The object of the association is to promote and record progress in the improvement of highways and the efficient development of highway transport throughout the world. The work of the association consists in organizing and conducting international road congresses, publishing the proceedings of its congresses and other documents, and collecting information relative to highway improvement and highway transport. A bulletin of the association is issued four times each year. The bulletin contains complete minutes of the meetings of the Permanent International Commission and the Permanent Council, announcements by the Executive Bureau, and progress reports on highway engineering and highway transport practice throughout the world. Each member, who resides in the United States, receives copies of the English editions of all proceedings, bulletins and other literature published by the association.

The membership of the association consists of representatives of Governments and Corporations, and individual members. The business affairs of the association are managed by the Permanent International Commission, which is composed of members representing the various Governments having membership in the association. Each Government has the right to one representative for each 1,000 francs of its total annual subsidy, provided that the number of representatives from any one government does not exceed fifteen. Unfortunately, the United States Government is the only World power which has not been affiliated with the association.

The first international road congress was held in Paris in 1908. At this Congress, the Permanent International Association Road Congresses was formed with headquarters in Paris. The second congress was held in Brussels in 1910. Following the second congress, the Permanent International Commission adopted a resolution to the effect that an international congress should be held every three years. The World War, of course, interfered with this program after 1913.

The Third International Road Congress was held in London in 1913, and was attended by 3,793 members, of which 139 were from the United States. Fifty-two Nations were represented at the Congress, 44 Governments having official representatives. The business sessions of the Congress occupied about one week and were devoted to a thorough discussion of 149 reports pertaining to the 19 topics on the program of the Congress. During the final business session, progressive conclusions relative to every main topic were adopted by the congress. The reports, which were presented by reporters from 19 nations, and the proceedings of the Third Congress measure, when stacked, about 6½ in. by 9½ in. by 8 in. in height.

Automobile and Truck Production in June.—Figures received by the Department of Commerce show a further increase in the June production of passenger automobiles and trucks. The total production of passenger cars in June, so far reported, amounted to 261,963, compared to 231,724 in April. This is an increase of over 11 per cent for the month. The total truck production in June was 25,912 machines, compared with the revised figures of 23,803 in May.

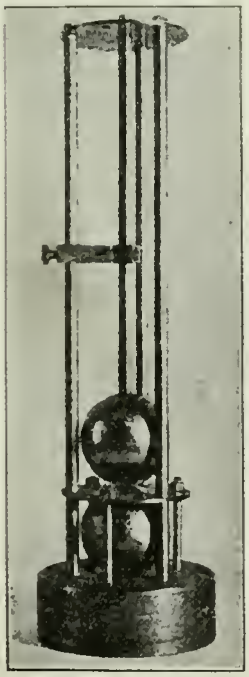
An Impact Test for Gravel

A simple portable apparatus devised at the U. S. Bureau of Public Roads which may be used in testing gravel aggregate for the purpose of determining the percentage of soft, disintegrated fragments present, was described by F. H. Jackson, Senior Assistant Testing Engineer of the Bureau, in a paper presented at the last annual meeting of the American Society for Testing Materials. An abstract of the paper follows:

The test supplies, the writer believes, a growing demand among highway engineers for a simple yet fairly reliable method of determining the quality of gravel aggregates. Both producers and users of this material know that gravels from many deposits otherwise satisfactory often contain enough excessively soft and unsound fragments to make their use inadvisable in concrete road construction. In the absence of specific tests, however, it is very difficult to draw a definite line of demarcation between satisfactory and unsatisfactory quality so that when it comes to the actual acceptance or rejection of materials the engineer must fall back upon his own judgment—a doubtful method at best.

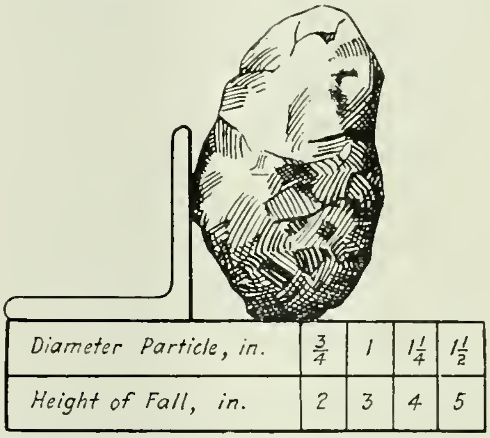
Although we have used for many years a number of more or less satisfactory tests for determining the quality of rock to be used in road construction, there has been, so far as the writer is aware, only one method used for making the corresponding tests on gravel. This is the modified Deval abrasion test devised by Rea several years ago and used to a considerable extent in a number of laboratories. The results of a large number of tests made in the laboratory of the U. S. Bureau of Public Roads on gravels from every section of the country indicate that, for general application, this test is not particularly satisfactory.

There is some question, however, whether any test at all for abrasion is necessary in the case of gravel aggregates. Laboratory investigations by Abrams indicate apparently that the wear of concrete is not dependent as much on the quality of the coarse aggregate as has been commonly supposed. Observations of gravel aggregate concrete roads under traffic have shown likewise in almost all cases that the actual wear on the pavement is practically negligible. An action which is much more frequently noted is the pitting of the surface of a concrete road due to the breaking up of excessively soft or unsound pieces in the aggregate, which, in the process of finishing, invariably find their way to the surface of the pavement. This is the material (shale, decomposed granite, very soft sandstone, etc.) that we want to detect and reject, and the writer believes that a simple impact test such as is here described, will answer the purpose. Although called an impact test, however, it must be understood that there is no attempt made to determine the actual resistance to impact or toughness of individual fragments in the same sense that a toughness test of rock is made. In the first place, due to the many variables present, it is next to impossible to do this, and in the second place, even if it were possible, it would not, in the writer's opinion, be necessary. The test, therefore, is designed simply to differentiate between satisfactory and unsatisfactory materials as measured by the ability of each fragment to withstand a single blow of a hammer of known weight, the height of fall being such that only very soft or unsound, decomposed pieces will fracture. In other words, the test simply attempts to define in terms of numerical values the usual specification phrase "shall be composed of sound, hard, durable particles."



Description of Apparatus.—The apparatus, a view of which is shown in Fig. 1, consists essentially of two 2½-in. steel balls, the lower ball fastened rigidly to a cast-iron anvil measuring 5 in. in diameter by 1¾ in. high and the upper one free to fall between three ⅜-in. guide rods. An adjustable stop, provided with a clamping nut, slides on one of the guide rods. Fastened rigidly to the upper ball is a ⅜-in. rod graduated in inches, which passes through a hole in the stop. The hammer, consisting of the upper ball and the graduated rod, weighs exactly 1,200 g., while the remainder of the apparatus weighs exactly 6 kg., so that the ratio of the weight of the hammer to the weight of the anvil is 1 to 5.

The operation of the test is extremely simple. The fragment to be tested is held firmly on the lower ball between the thumb and the first finger of the right hand so that its smallest diameter is vertical. The upper ball is then allowed to rest on the test specimen and the stop adjusted at the height of fall desired, measured in inches directly on the rod. The stop is then clamped in position, the upper ball raised until in contact with it and allowed to fall upon the specimen. A very little practice will make an operator adept in holding the specimen in place without difficulty. It is possible also in almost every case to secure a reasonably firm bearing on the lower ball. This may be done by trying the specimen in various positions, allowing the ball to drop in each case from a very small height, say ¼ in., and noting the effect.



Diameter Particle, in.	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$
Height of Fall, in.	2	3	4	5

Fig. 2.—Scale for Determining Height of Hammer Blow for Particles of Various Diameters.

The relative height of fall for fragments of various diameters has been determined tentatively in the following manner:

A large quantity of soft limestone of uniform quality was obtained. When subjected to the usual stone tests, this sample showed a percentage of wear of 11.0, a toughness of 3, and a hardness of 8.0. The material was broken by hand into pieces approximately 2 in. in diameter and under, and then run in the Deval abrasion machine until all the fragments had become rounded. This produced an artificial gravel of uniform quality and yet one which was obtained from rock too soft for use as concrete aggregate. The material was then divided into various groups of sizes differing in minimum diameter by ¼ in. as follows: Size No. 1 was composed of pieces, the minimum diameter of which varied from 1⅜ to 1⅝ in.; size No. 2 from 1⅛ to 1⅜ in.; size No. 3 from ⅞ to 1⅛ in.; and size No. 4 from ⅝ to ⅞ in. Fifty pieces of each size were selected and the height of blow required to fracture each was determined. These values were obtained by subjecting each specimen to a blow from a height of 1 in. and then increasing the height of fall by 1-in. increments until failure. The average results for each size of particle are as follows:

TABLE I.

Size No.	Minimum diameter, in.	Average height of blow at failure, in.
1	1½	5.2
2	1¼	4.1
3	1	3.0
4	¾	2.1

These figures seem to indicate that for a material of uniform quality a fairly definite relation exists between the height of fall and the diameter of the particle. Having established this relation, the next step is to determine the proper height of fall which, for particles of a given size, will fracture only unsound or otherwise objectionable pieces. This can only be done after considerable further experimentation. A tentative method of test has been decided on, however, using the values given in the table above with the understanding that they may be modified later if necessary.

Tentative Method of Test.—The material to be tested is accurately quartered down until a sample is obtained which contains from 25 to 50 pieces ranging in size from ¾ to 2 in. in diameter. Care should be taken to see that the various sizes appear in about the same proportion as in the original sample. The pieces thus obtained are then tested individually by first determining the average diameter across the shortest dimension and then subjecting each to a single blow of the hammer from the height called for in the table. Flat pieces whose longest diameter is over three times their shortest diameter are not tested. A convenient scale for measuring the diameter of a particle is shown in Fig. 2. In using this scale, a fragment is held against the stop so as to measure its least diameter along the upper scale. The proper height of fall is then read directly on the lower scale. The average time required to test a sample by this method is approximately 20 minutes.

A number of gravels of various types have been tested with this apparatus and the results so far seem to indicate that the instrument will serve the purpose for which it was designed. It must be borne in mind, however, that the limits set in the table are purely arbitrary and may have to be modified after further experimentation. The point to be emphasized is that the energy of the blow to be delivered must be just great enough to fracture unsound or disintegrated fragments. For this reason the limits set in Table I, based on the use of very soft stone, appear to be on the safe side.

A point in connection with the test which has not yet been worked out is the question of the allowable percentage of soft pieces in gravel aggregate. The Bureau of Public Roads hopes to obtain considerable information which will assist in determining this limit during the present season in connection with an accelerated wear test now under way at Arlington, Va. As a part of this experiment a number of concrete sections containing gravel aggregates of various types are being studied and their behavior under test should materially assist in establishing a specification limit of allowable percentage of soft pieces as measured by the proposed test.

Tractive Resistance of Roads Studied

Initial results secured from an investigation of the tractive resistance of roads indicate that information will be secured of great value to the highway engineer and the user of motor transport. The investigations are being carried on under the auspices of the Advisory Board on Highway Research of the National Research Council with which the Bureau of Public Roads, United States Department of Agriculture, and the Quartermaster Corps, United States Army are co-operating.

One phase of the investigation shows that there is a great difference in the power required of the engine when a truck is traveling over different types of surfacing, the amount being more than twice as great on some of the lower types when compared with that on higher types. It is also shown that the power required to overcome the road resistance is not proportional to the speed of the vehicle and after a certain speed is reached increases very rapidly.

The investigation when complete will cover tests with various types of motor vehicles with the load, tire, and spring equipment varied on different types of surfacing and at varying speeds. The data will include gasoline consumption, internal engine resistance, wind resistance, and road-surface resistance.

When carefully analyzed it will aid the highway engineer in determining under a given set of conditions what type of surface should be built for a given volume of traffic to result in the least total cost for road and vehicle operation. The same sort of study will be made as to expenditures for grade reduction to reduce operating costs.

The truck operator will be given valuable information on the effect of tire and spring equipment, lubrication, size of load and speed of vehicle on fuel consumption which should aid him in producing cheaper transportation.

Need of Educating Public to an Appreciation of Magnitude and Importance of Highway Construction*

By A. R. HIRST,
State Highway Engineer of Wisconsin.

Possibly a good many of us, working in our small individual fields of highway work, are a little apt to lose sight of the fact that during these last few years and in the years to come, we are going to live through one of the greatest romances of all engineering history. We are too apt to localize our viewpoint to our especial field in this work, but it is true that in these American states we are undertaking the greatest engineering enterprise in the history of the world, in this attempt to build a highway system. The United States Bureau of Public Roads says that we are going to spend on federal, state and county highway work this year $700,000,000. This is a lot of money and in the expenditure of it, we, as engineers, are expected to see that it is honestly and well done, but we feel in Wisconsin that life is not worth living unless, as you go through it, in addition to performing that work which we must perform, we get some pleasure out of it. After all, as we pass through life, we engineers can never hope to gain any money. The only thing we can gain is the consciousness of doing well those things we have to do and to have a little fun and pleasure as we go through with our work.

In 1921 we built in Wisconsin 3,600 miles of road, including 340 miles of concrete, and 2,300 miles of gravel and incidently we constructed 800 bridges over 10 ft. in span. But these things did not bother us at all. The thing which bothered us and which bothers all of us is the attitude of the public toward this great enterprise. The railroads in the five years between 1879 and 1884 built several thousand miles of railroad but they did not build within that period one-quarter of the highway mileage that we are building during the present five years and they did not spend one-fourth of the money. They paid engineering talent quite well in those days. They turned them loose on the construction and, in general, the construction was performed as a straight forward engineering matter.

The Pay of Highway Engineers.—While we are drifting somewhat away from the subject, I wish to say that the most important American highway problem today is whether we can educate the American people to appreciate the magnitude and the importance of this job. Prof. Blanchard kindly stated that I was a fighter for higher salaries. I am, I have been, and I always will be. Not because I want more money myself, but when the state of Wisconsin is spending $30,000,000 and every other American state of any wealth is likewise spending millions, it has become a matter of the greatest importance that this money be spent honestly and well by engineering organizations of skill and efficiency. After all, the people of the states are going to get just about what they pay for and the counties the same, and so, also the smaller governmental divisions.

The best paid highway organizations in the United States, considering relative responsibilities, are some of the county highway organizations. The next best, or I should say worst, paid are the state organizations, and the very worst paid are the federal men. Our good friend, Thos. H. MacDonald, a wonderful man and engineer, receives the munificent compensation of $6,000 a year. We must by every means in our power fight for progress in this matter. We must fight for the proper standards of organization and efficiency. We must concentrate upon this and ding at it insistently because if we are going to spend at the rate of $700,000,000 a year and more for highways, the organizations which spent it cannot be too efficient, and efficient is just another word for well-paid organizations.

The Politician and the Highways.—The politicians in America have played with the highway game for several years. Some of them have found that it is a very expensive thing and a dangerous thing to play with, and those states are clearing up. But until the governors of all the states learn that here is one thing which they cannot afford to meddle with in a political way, the American people will continue to have very expensive lessons. As a matter of fact it is astounding they have not gotten worse than they have so far.

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*Paper read at the 8th Annual Conference on Highway Engineering at the University of Michigan.

It speaks well for the honesty and efficiency of the engineering profession which has given to the states and counties the service which they have received, at the price they have paid. We are meeting in the engineering field a very severe competition from contractors and material and machinery companies.

The state legislatures have not awakened to the fact that this is about the sole public enterprise in which the state and counties are in a competitive field. They are so used to having as officials, largely men who could not make a living in any other way, that it has gone down the line that a man who is employed by the public must necessarily be a loafer, a grafter or an incompetent.

We must teach and preach that this highway enterprise is entirely different from the ordinary run of public offices, which are usually held in America either by men who have been or by men who hope to be. We are trying to build up organizations which will be a permanent field of service for the life-work of young men, and if we are going to attract the best young men, we must offer the proper environment in which they are to work.

Highway Traffic Must Be Served.—In talking highways we are too apt to think of highways in terms of specific details. The romance of the highway game, the thing which keeps me in it 16 hours a day, is the fact that we are seeing develop before our eyes, the greatest growth of transportation ever known in the history of the world, and we are supposed to take care of it from day to day and from year to year. We have in Wisconsin approximately 350,000 motor vehicles. They travel over our highways 1,250,000,000 miles a year. If we can save them 1 ct. a mile, it would mean a $12,500,000 a year saving to this traffic.

When I started out in the highway game something like 14 years ago in Maryland when we had a few automobiles, we built waterbound macadam roads at a cost of about $4,000 a mile and we thought they would last forever. The same kind of a highway that we built in Maryland would last about two weeks on one of our main traveled roads today.

This mass of transportation service which we must oversee, exceeds the railroad transportation. We accommodate more passengers than all the railroads in Wisconsin combined, ten to one. All kinds of railroad trains run 13,000,000 miles a year in Wisconsin and our motor vehicles run 1,250,000,000 so you see it has become a problem of magnitude.

We must build highways as fast as we can get our taxpayers to pay for them. We must recognize the fact that highway traffic is the thing to be served and that the details as to whether we build 1,000 or 3,000 miles each year is rather immaterial. The thing to get hold of is the matter of serving traffic, not five years from now, but right now.

Highway Construction in Wisconsin.—In Wisconsin we started in 1918 by taking over a system of 5,000 miles of highways just in the condition it happened to be in. We have maintained them from that time, adding 2,500 miles two years ago. In addition our counties are maintaining 5,000 miles of secondary roads, making a total of 12,500 miles of road maintained in Wisconsin under the patrol system.

We spent last year $4,000,000 for maintenance and $24,000,000 for construction, but if I had to stop either construction or maintenance, I should see that the maintenance was kept up, because in that way we can accommodate a greater number of people.

When we took over the system in 1918, a man could average about 15 miles an hour in the summer season. Today we drive the distance of 25 and that is the number of hours it takes to cover the distance, and we can even do a little better in some sections. Michigan has duplicated these results and so has Minnesota. We have all simply tried to do the best we could with what we happened to have when we took over the systems.

I have often said that the minute a state or a county adopts a system of highways which it says it is going to construct some time, upon that day it must take over the maintenance of that system. Some of the eastern states, on the other hand, have been building a highway system for decades. They have almost finished them now and there has never been a period in the meantime that one could go from one end to the other of those states without getting stuck in the mud at the proper seasons of the year. The states maintained the roads they had built but the roads which they had not built were not maintained. That policy is wrong. Just as the Michigan Central R. R. or the Baltimore & Ohio or the Pennsylvania seeks first to get the traffic through at almost any cost, just so must the states and counties get their traffic through if they possibly can, and it is surprising what can be done if you will only persistently keep after them.

A concrete road is a wonderful road. We have about 1,000 miles of it. We built about 350 miles last year and we expect to build about as much more this year. We are building hundreds of miles of gravel roads. But although we started in highway work in 1907, after all these years, of the 7,500 miles of the most important highways, we have surfaced only about two-thirds and of the mileage surfaced, less than 13 per cent is concrete. So we still have a long way to go. When the state aid law became effective in 1912 several counties were opposed to it because "they said they had built their roads and they did not wish to help other counties to build theirs." But four of these counties have bonded during the last year to build concrete roads, since the roads they had are not now adequate for the traffic upon them. Hence that is one advantage in our work. It is never done. We have always to rebuild old highways or to build more of them. But we can justify what we have spent on roads in the last few years and we can also justify the building we did 10 or 15 years ago.

The Education of the Public.—We have got to simply sell this romance of ours. We have got to convert the people from thinking of the thing merely as a matter of dollars and cents. There will be no complaint if we deliver to the people one hundred cents on the dollar. Our highways do not come from a state highway department of from a university. They come from the legislatures of the states. They come from the county boards in the various counties. There is the crux of the situation. There is where the money is provided and the laws made which make it possible for us to build roads and there is where the conditions under which we are to operate, are created.

If more engineers would turn their attention to this end of the game, the matter of the education of the public, the legislatures and county boards, which after all reflect the desires and purposes of the people, and pay possibly a little less attention to the science and theory of construction, concentrating themselves upon this for the next three, four, or five or ten years and educating the public to an appreciation of this public work, we will get our results a good deal faster and easier. I am familiar with the highway results in America. I know what we are doing in the middle west and I had the pleasure of taking a trip through the eastern states and I came back from that trip well satisfied that, after all, the American people have gotten pretty good value out of all they have spent for highways in the last five or ten years, whether the roads were built of gravel, macadam, concrete or brick. In general, they were giving all the services they could be expected to give and the American people will get out of them all they put into them and more.

We have had too much worry about the millions of dollars that have been wasted. Very few of them have been wasted. Wisconsin, Minnesota and Michigan have built large mileages of low type roads, gravel and macadam, for which we have been criticized. In most cases we got those roads complete, including surfacing and culverts, for less than the grading and culvert work could be done for today. They have had these surfaces for all these years and they will make a good foundation for future work. They talk about some of our old concrete roads in Wayne County and Milwaukee County and others as having cracked badly. They are worth more now as a base for any other kind of pavement we may wish to put on than they cost ten years ago; they are not lost.

Proper Location of Highways.—The most important thing, in my opinion, after the necessary education of public sentiment, is that we should consider the problem of proper locations of highways. If the states have lost anything in their highway investment, it has been because we have not looked far enough into the future. We have not located well enough.

Let us get into figures. A highway which carries 500 vehicles as a maximum a day in the summer season and drops off the rest of the year is a light traveled highway but even on this highway one mile of extra distance, costs travel over this road approximately 123,250 miles a year and the cost of this extra traffic at 10 ct. a mile is for each mile the interest of 5 per cent on $246,500.

Take the matter of detours. The question is whether to put in a detour or accommodate traffic by building a temporary road or bridge. Taking the average summer road in Michigan or Wisconsin with 500 vehicles a day, a three mile extra detour means 1,500 miles a day. If the road is closed for 90 days, it means $13,500.

Those are the kind of figures we are dealing with. The cost of highway traffic is paid by millions of people. We have just exactly the same problem in taking care of this traffic that the railroad has in taking care of its traffic. We can lose just as much as they could by the unskillful handling of this traffic.

In my opinion, in many cases, rather than to use a bad detour, it would be much better to ditch the old right of way and build a new road parallel to it and let traffic use the old road while the construction of the new road is going on. It would cost the people less money, and the same is true of bridges.

In Wisconsin we are locating the highways so that, whenever possible, we build the bridge parallel to or near the old bridge, using the old bridge while constructing the new one. It is sometimes very hard to educate the people to that state of mind. They do not realize when they are saving and when they are losing money.

I made the statement at Omaha that the state highway department which was not being severely criticized because of its drastic relocations and treatment of distances, curves, and railroad crossings was failing in its duty as a state highway department. The Wisconsin Department is severely criticized. The people think some of our plans are too drastic, but for the 50 years between 1860 and 1910, the farmers and the towns of Wisconsin were so busy in unrelocating highways, that we have had an awful time to catch up with them. It was the era of squaring fields and time after time, to the extent of dozens of miles we have bought back from the farmer the old right-of-way on which the pioneers put the highway, but which was later abandoned in order to square fields. What they took from the public for nothing we are buying back and paying thousands of dollars for.

The location of gravel roads is not quite so important but concrete roads cannot be located too well. There is no reason to believe that we are any more foresighted now than we were five years ago. I don't believe that any State Highway Department can get away with a program of highway location which is too drastic because before they do, they will be overturned. The art in this business of highway construction, maintenance and location is to go just as far as you can possibly go and get away with it. Sometimes some one goes too far and does not get away with it. The thing we want to look out for is that we are steering close to the rocks all the time in this matter of proper location and proper widths and proper types because only in that way can we be sure that we are nearly right and that our successors will not criticize us for being blind to the probable development of traffic.

State Highway Maps.—We are all going more and more into maintenance and into the things which accommodate traffic. One of the most important things is to prperly guide the traffic and to do this we have published for several years a state trunk highway map of Wisconsin. We have issued and sold each year over 40,000 of them. In addition to being engineers we have become map makers and salesmen. This year we are going to change our map so it will show the type of the highway, so that one can tell what kind of a road he will find in any direction and can choose the best to travel over whatever the kind of weather. Also last summer we started a detour map service. We issue this map weekly. It shows the roads under construction and roads open to traffic and the detours. These maps were posted at about 80 garages and hotels around the state and any one can look over the routes and find out just what trouble he may encounter if he chooses a certain route or what trouble he may avoid by choosing another. This information comes in from our district offices on Monday of each week, the corrections are made in our main office and the maps are mailed out Wednesday, so we give reasonably quick service. This public service is just one of very many new phases of highway work.

In my opinion, of all the lines of civil engineering, if a man really goes into it with vision, highway engineerng offers the most wonderful opportunities for true engineering accomplishment that were ever offered in the history of mankind.

Research on Tractive Resistance of Roads

The present state of research on tractive resistance of roads was considered by prominent research specialists at a conference called in Washington by the Advisory Board on Highway Research of the National Research Council on July 14 and 15. The relation of the highway to the automotive engineer and the research planned in this field for the near future also came up for discussion.

Reports on researches now actively under way were made by Prof. T. R. Agg, Dr. H. C. Dickinson, A. T. Goldbeck, Major Mark L. Ireland, W. S. James, Dean A. N. Johnson, Prof. W. E. Lay and Prof. E. H. Lockwood.

A committee consisting of Prof. C. A. Adams, T. R. Agg, Dr. H. C. Dickinson, A. T. Goldbeck, Major Ireland, W. S. James, A. N. Johnson, W. E. Lay, E. H. Lockwood and Prof. C. J. Tilden, was appointed to draw up a statement of principles.

Dr. W. K. Hatt, Director of the Advisory Board on Highway Research presided at the conference and C. R. Ege, H. S. Fairbank, D. C. Fenner and Pyke Johnson were also in attendance.

The report of the committee as adopted is as follows:

Definitions: Rolling Resistance, is the resistance to translation arising from the interaction of road and vehicle, but excluding resistances in the engine and transmission system.

As ordinarily measured this includes wheel bearing resistance, which in case of well conditioned cars should not exceed 5 lb. per ton. Rolling resistance by the definition also includes the resistance in the framework and spring suspension system of the vehicle arising from the road. Rolling resistance as measured contains various degrees of impact effects and road displacement effects depending upon the condition of the road and design of the vehicle. Resistance due to horizontal curvature of road should be measured in the experiments.

It is the purpose of tests of rolling resistance to determine the force at the rear axle (or tire periphery) necessary to move the vehicle, as conditioned by road surface, type of road, tire equipment, class and weight of vehicle, etc.

Air Resistance: Resistance arising from relative velocity of air and vehicle.

Ordinarily this resistance is included in tested resistance, and should be subtracted to obtain rolling resistance. Investigations are needed to determine the law and coefficient of this resistance for various vehicles.

Rolling and air resistances are those resistances determined when a vehicle is towed with the power transmission mechanism disconnected at the rear wheel. However, the difference between a self-operated and a towed vehicle in respect to tire losses and slipping may make some difference in results, especially at high speeds.

Having the rolling and air resistance, it becomes the function of the automotive engineer to design an efficient vehicle to furnish power for economical transportation over various alignments.

Transmission System Resistance: Transmission system resistance is the force required at rear axle, or tire periphery to overcome all internal resistance from the clutch to the rear axle.

The transmission system resistance depends upon the gear ratio in mesh and the power transmitted, as well as upon other conditions such as speed, temperature of lubricant, etc. These losses are best determined in the laboratory.

Engine Resistance: Engine resistance is the force required at the rear axle or tire periphery to overcome the resistance of engine, including cooling system, fan and accessories.

Engine resistance depends upon the operation of the engine as regards throttle opening, speed, temperature and mechanical condition of the engine. These resistances are best determined in the laboratory.

Equipment and Instruments: Rolling and air resistance should be measured for basic types of motor vehicles and tractors. For purposes of comparison of economy of types of roads, expressed in gas consumption, time of translation, and other costs of maintenance of vehicle and road, the rolling resistance should be measured to an accuracy of within 5 per cent.

The present state of the art indicates that at low speeds up to 10 miles per hour, a traction dynamometer of the liquid pressure type, or a space-time recorder is considered best fitted. At higher speeds, a space-time recorder, or a U tube accelerometer is most satisfactory. New instruments should be investigated, especially the torsion dynamometer.

Tests should be made of adhesion of tires on road surfaces under running conditions to determine safety against skidding under various conditions of brake and tire equipment and road. The use of an accelerometer with locking of brakes is recommended.

The Relation of the Automotive Engineer to the Highway Engineer: The automotive engineer needs data of rolling and air resistance rather than data of gasoline consumption from road tests, since the latter depend upon individual characteristics of vehicle used, carbureter, habits of driver, etc. Having the power factors, the automotive engineer will design the plant to furnish the power required.

From the standpoint of the highway engineer, a problem like the following is set:

A reduction of grade of 4 ft. will reduce energy required an amount of 8,000 ft. lbs. What will this be worth in saving of gasoline and other operating expense for traffic considered? Will the solution be for cars as at present built, or for cars using these roads 15 years from now? The mutual relation of highway and vehicle is expressed in the effect of low grades on changes in engine design and power requirements of car. Inasmuch as the large expense of highway transportation is in expense of operation of transportation rather than in fixed charges and maintenance of road, the investigation of costs of operation of traffic is particularly needed.

It is estimated that a 5 per cent grade on a hard surfaced road is not considered excessive for passenger cars, and 2 per cent to 3 per cent for heavy capacity trucks.

The fuel cost and time required, as affected by type and design of surfaces and grades, is measurable by experimental methods, and the depreciation of the vehicle and other maintenance costs should be evaluated from a study of the statistics of motor vehicles obtained in actual operation.

Fellowships in Highway Engineering and Highway Transport at University of Michigan

Two of the following fellowships will be awarded not later than September 1st and two not later than Nov. 1, 1922, by the Board of Regents of the University of Michigan:

The Roy D. Chapin Fellowship in Highway Transport, which is offered to provide for the investigation of an approved subject relative to highway transport.

The Roy D. Chapin Fellowship in highway engineering, which is offered to provide for the investigation of an approved subject relative to hard surfaced roads and pavements.

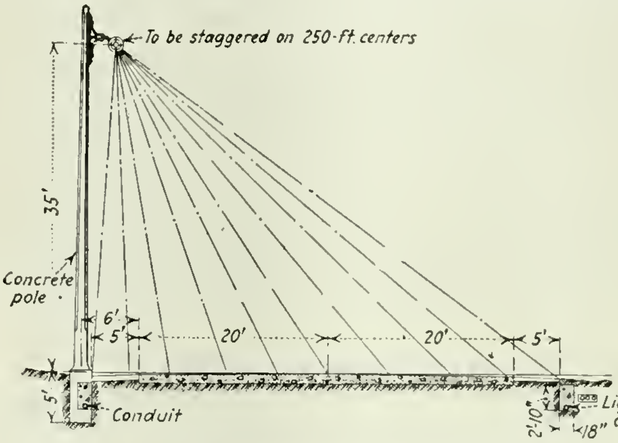
Two Detroit Edison Fellowships in highway engineering, which are offered to provide for the investigation of approved subjects relative to moderate cost country roads.

General Conditions: Each fellowship pays the sum of $250 with an allowance of $50 for expenses. The holders of these fellowships do not have to pay tuition fees. A fellow must hold a bachelor's degree from a college of recognized standing. He must enroll as a graduate student in highway engineering or highway transport and as a candidate for the degree of master of science or master of science in engineering. He must be in residence for one of the following periods: First Semester (October to February); Winter Period (December to March; Second Semester (February to June). An application for a Fellowship must include a concise statement of the candidate's educational training and engineering experience, and three references. Applications and requests for information pertaining to the twenty-five advanced courses in highway engineering and highway transport offered by the graduate school should be sent to Professor Arthur H. Blanchard, Engineering Building, University of Michigan, Ann Arbor, Mich.

Coal Elevator Forms Part of Central Mixing Plant.—An efficient central concrete mixing plant for paving streets in Collingswood, N. J., was made by placing a building mixer alongside a retail coal elevator. Bins inside the elevator were filled with aggregates by the coal handling apparatus. The aggregates were fed to the measuring boxes over the mixer by chutes cut through the wall. The cement was handled direct from cars by a small elevator.

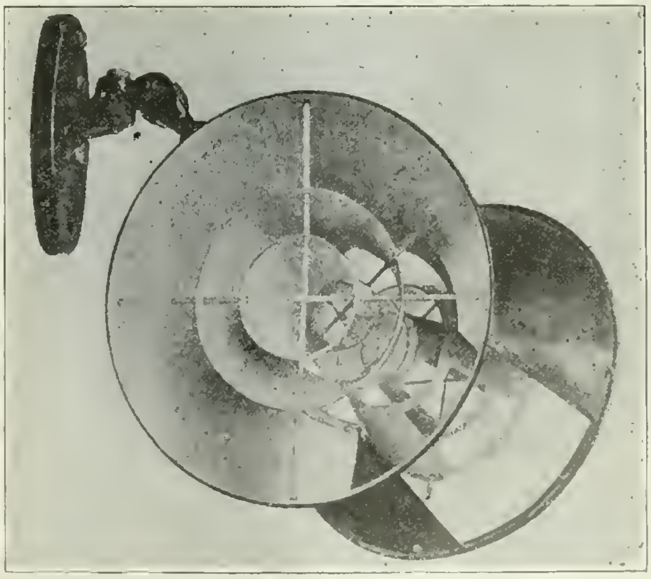
Improved Lighting System on Lincoln Highway

Constantly increasing night travel by motor vehicles has brought about a demand for improved highway lighting. Equipment intended for lighting city and village streets is not suitable. Hence a new system has had to be developed. This system has recently been successfully used in several places, notably on the Albany-Schenectady highway, and is now to be demonstrated on a 1½-mile section of the Lincoln Highway in Lake County, Ind. Preliminary plans for lighting it have been approved by the technical committee of the Lincoln Highway Association. Features of these plans are described by H. H. Bell, of the Illuminating Engineering Laboratory of the General Electric Co., in the Electrical World, from which our illustrations and text are taken.



Typical Section Across Lincoln Highway.

Before the system was developed it was necessary to determine the essentials of a satisfactory lighting unit. The most important were: (1) Concentration of the light on the roadway instead of diffusing it upward and over the adjoining fields; (2) a flexibility of arrangement that would make it possible to keep the light in line with the surface of the roadway under any condition, thus permitting the units to be placed on poles either near the road or some distance from it and to illuminate curves and grades, this plan necessitating a bracket that would permit adjusting the unit in both a vertical and a horizontal direction; (3) reasonably moderate cost of installation, operation and maintenance.



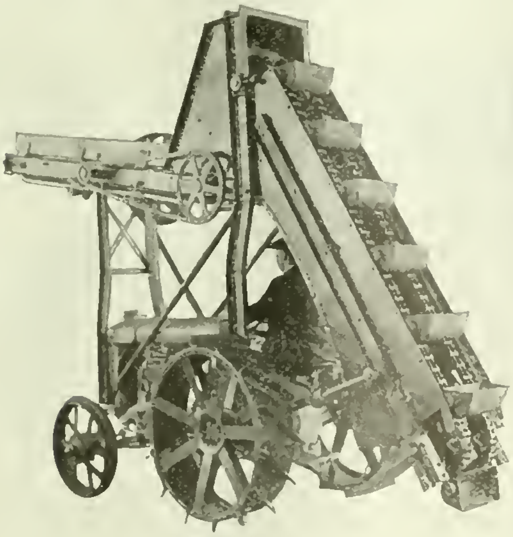
Bracket Type Series Highway Lighting Unit.

Obviously, units designed for lighting city or village development of a highway lighting unit with a parabolic nest reflector and embodying certain new features for collecting the light rays and directing them where most needed. Described in simple terms, it consists of a nest of three reflectors, one within another, and with an opening in each, one each side of the lamp. By this means the greater part of the light that would be lost under ordinary conditions by reflecting upward and outward to the adjoining fields is collected and cast in both directions on the surface of the roadway. The rays that would escape if only one reflector were used are picked up by the inner reflectors and directed toward the roadway at an angle of 10 deg. below the horizontal. Two single parabolic reflectors to give the same effect would have to have approximately 15 ft. spread. The white reflecting surfaces of the unit reduce the glare, which might be objectionable if polished surfaces were used. This fixture also gives a much better distribution of the light rays than that given by the types of reflectors now in use along some highways on the outskirts of cities. The bracket holding the reflector is adjustable in both a horizontal and vertical direction, making it possible to mount the fixture either on poles near the roadway or on those some distance from it and providing for turning it so as to illuminate curves or hillsides.

The Lincoln Highway lighting units are to be spaced on 250-ft. centers, staggered, the distance from the road surface to the light center of the lamp to be 35 ft. They are to be mounted on concrete standards, and these standards are to be placed along the outer edges of the gravel shoulder. The lamps will be 2,500 lumen (250 c. p.) "Mazda C" series lamps, operated from a constant current supply 6.6 amp.

Portable Loader with Tractor Power Plant

A portable loader for sand, gravel, stone and other loose material which utilizes a Fordson tractor as its power plant both in driving and traction, has been placed on the market by the Specialty Engineering Co., Trenton and Allegheny Aves., Philadelphia, Pa. The loader is operated from the power take-off shaft of the tractor. The elevating equipment consists of steel buckets operated by endless chains and working on rollers, the latter being a distinctive feature. The material to be loaded is lifted by the elevator and delivered to the conveyor which extends across the top of the tractor. The conveying mechanism is of the conventional endless apron type and moves the material forward beyond the front end of the tractor, where it is dumped into trucks or wagons. The outfit can be easily moved as fast as loading conditions require. It backs into the material to be loaded and the trucks hauling the material are loaded from the front of the tractor. In moving from one job to another, the elevator is raised so that it has the same clearance as the tractor. Its overall height is sufficiently low to permit it moving under viaducts, in and out of service stations, etc. The loader weighs approximately 3,500 lbs., 80 per cent of which is carried on the rear axle.



Specialty Portable Loader.

Longitudinal Floats for Concrete Road Construction.—Longitudinal floats are being used to a considerable extent in concrete road construction in Los Angeles County, California. The float is 15 or 20 ft. long with a wide trowelling surface. It is operated from bridges with its length parallel to the center line of the road. It will turn out any longitudinal waves that may have escaped the template or roller.

How Much Should Be Spent on a Road Improvement

Relation Between Cost and Traffic Pointed Out in Paper Presented at Regional Conference at Agricultural and Mechanical College of Texas

By N. W. DOUGHERTY,
Professor of Civil Engineering, University of Tennessee.

Cost and Traffic.—To measure traffic, some unit must be used. In railway transportation the train mile, the ton mile or the passenger mile is used; in highway transportation the vehicle mile, the ton mile, the package mile or the passenger mile may be used. For a general discussion the vehicle mile is as good a unit as may be found. In any section of the country or on any particular road, a definite sum of money will be needed to own and maintain any particular type of surface. The sum needed will depend upon local conditions and the type, but in any case the annual cost may be determined. The amount and kind of traffic may be determined by placing counters on the road. The future traffic may be approximately estimated by studying the factors which cause traffic to vary.

In railway operation the accounts are so kept that it is possible to compute the part each item is of the total cost of operation. Maintenance of way and structures make up approximately 20 per cent of the total. In highway transportation it is more difficult to get accurate costs of operation. The operation is carried on by the whole population and not by one operating department. The items of investment, maintenance of way and structures, however, are cared for by the highway departments which should make, at least, approximate costs available. It will be noted that the maintenance and upkeep of the highways correspond to the same items in railway operation. It is the business of the highway departments to furnish and maintain a roadbed which will carry the traffic with as small operating charge as possible.

Let the annual cost of a mile of road be represented by C, the daily traffic by T; then the cost per vehicle mile will be $V = \frac{C}{365\,T}$ or $VT = \frac{C}{365}$, which is the equation to a hyperbola. A figure can be readily drawn which shows this relation for, say, $500, $1,000, $2,000 and $3,000 annual costs.

If the traffic is 200 vehicles per day and the annual cost is $1,000 per mile, the vehicle mile cost is 1.37 ct.; if the traffic is 2,000 vehicles per day the cost is 0.137 ct., and if it is 20 vehicles per day the cost is 13.7 ct. It is therefore obvious that there is a minimum traffic which will justify an annual expenditure of $1,000. The same reasoning will apply for any other sum as an annual expenditure.

Vehicle Mile Cost.—Is it possible to arrive at a vehicle mile cost that may be considered reasonable? As stated before, the cost of maintenance and structures in railway operation is approximately 20 per cent of the total cost of operation. On the average, if it costs 10 ct. to transport a consignment of freight or a passenger from one point to another, 2 ct. of this cost is due to maintenance of way and structures. Where the volume of traffic is largely auto traffic, the cost of operation, exclusive of the cost of the highway, will not be less than 5 ct. per vehicle mile, and it will probably be more nearly 10 to 15 ct. per vehicle mile. Taking 10 to 15 ct. as the average vehicle mile cost and assuming 20 per cent of this sum as a fair highway expenditure, we may say that from 2 to 3 ct. per vehicle mile may be made without the expenditure becoming excessive. On certain toll roads in Tennessee, the toll gates are placed five miles apart and the charge for a five-passenged car is 25 ct. for the through traffic, or 5 ct. per mile. If the same vehicle returns during the same day, no charge is made for the return trip, making the charge for such vehicle 2.5 ct. per vehicle mile. These toll roads may be avoided by parallel routes, which are somewhat longer and which have poorer grades and road surfaces; still in some cases the traffic is heavy, making the roads very profitable. From these two items it seems reasonable to assume that 2 to 3 ct. per vehicle mile may be charged without making the expenditure excessive.

$$200 \times .02 \times 365 = \$1,460$$
$$200 \times .03 \times 365 = 2,190$$

Two hundred vehicles per day will justify an annual expenditure of from $1,460 to $2,190 per mile per year. Twenty vehicles per day would justify $146 to $219 and 2,000 vehicles would justify $14,600 to $21,900 per mile per year. It is thus seen that for a traffic of from 200 to 2,000 vehicles per day an expenditure may be justified that will be sufficient to own and maintain an improved surface that will carry this traffic throughout the year. If the traffic falls much below 100 vehicles per day it will be difficult to justify the annual sum of money that will be required to own and maintain an improved hard surface. This means that the low traffic roads must be low annual cost roads or the traffic charge will become excessive.

In making an estimate for a new expenditure, due weight must be given to probable future traffic. It is possible to roughly approximate the future traffic. In determining the initial expenditure which may be made the average annual cost over the life of the road should be compared with the average annual traffic over this period rather than the traffic at the beginning or the end of the period. Other factors enter into the first cost, but the traffic is primary.

Annual Cost.—The problem in hand is one of transportation rather than one of road building and road maintenance. Too often the problem has been considered as one of "good roads." It is not roads that are needed, but rather lanes of traffic. The annual costs should, therefore, be made up of the items which enter into transportation, which are: interest, depreciation, maintenance and operation of vehicles.

Some discussion may arise as to the interest charge. It is included as a differential interest rather than interest on the total first cost. The argument is advanced that property values will increase with the improvement and absorb the first cost. In some cases this is true. Any property value increase will be due to the satisfaction of a want, that want being a traffic need. If the need be served by expending $10,000, property values will be increased very little, if at all, by expending $40,000. In such a case it, therefore, seems reasonable to charge as annual cost the interest on the difference between $40,000 and $10,000. The highest class surface known, if constructed in the middle of the desert, will cause no enhancement of property values because there is no traffic need for the road. A sand clay road, where there is traffic to be kept out of the mud, may cause great increase in value of the adjacent property. If all the traffic needs are satisfied by a water-bound macadam with carpet treatment, an asphaltic concrete can do no more. Therefore, in comparing the two surfaces in places where both are satisfactory, certainly interest on investment should be included.

The second two items, maintenance and depreciation, should certainly be included. All are agreed on the inclusion of these items, but there is some difference of opinion as to what should be included in the one and the method of computing the other.

If the cost of operation, i. e., if the cost to get the vehicle over the road were the same on all types of surfaces, it would not enter into the road problem. The cost, however, is not the same on all types of surfaces and should, therefore, become a part of the annual cost. In making a selection of type, the difference in cost of operation is the factor which will influence the result. If, for example, the waterbound macadam with carpet treatment causes a greater demand on the gasoline tank, and cause greater wear on the horses' shoes and the auto tires than the asphaltic concrete, this difference in cost should be considered in making the selection.

Saving in Vehicle Operation.—In the preceding computations only the first three items named in the annual cost were considered in the cost of operation. To arrive at the true annual expenditure per mile that may be made, the saving in cost of operation must enter. Here the data available are very meager and only rough approximations may be used.

There is no question that it costs more, considering vehicle costs alone, to travel over a muddy road than it does to travel over a hard surface road. The exact saving is not known, though estimates have been made than range from 10 to 20 ct. per ton mile. The difference in cost on hard surface roads is far below this amount. It does not seem unreasonable to assume that this difference may be as high as 1 or 2 ct. per vehicle mile. When data are available, showing this relation, a more careful estimate of the justifiable annual expenditure may be made. One cent per vehicle mile, with a traffic of 200 vehicles per day, would give $730 per mile per year. This, added to the sums estimated above, would give a range of $2,190 to $2,920 per mile per year. This latter sum is sufficient to pay the upkeep on almost any type of two-way pavement that may be chosen.

The suggestion has already been made that the traffic may be served by less expenditure than the above computations could justify. The effort has been to arrive at expenditures that will be reasonable rather than expenditures that will care for the traffic. Certainly no expenditure should be made which will increase the vehicle mile cost when the traffic may be cared for at a lower figure. Since the problem is one of transportation, the cost to the traffic should be considered as primary. If the traffic can be carried on one surface at 0.1 ct. per vehicle mile, it is poor economy to raise that cost to 2 or 3 ct. per vehicle mile by poor choice of surface, even though the 2 or 3 ct. may be justified.

Conclusions.—There is a minimum traffic for which an annual expenditure of a fixed sum may be justified.

Knowing the traffic, an approximate reasonable annual expenditure may be computed.

On heavy traffic roads the vehicle mile cost should be far below the amount that may be justified on low traffic roads, or the annual expenditure that may be justified is large enough to furnish any type of surface now constructed.

Annual cost is made up of interest, depreciation, maintenance and cost of vehicle operation.

In making an economic selection of type of surface annual cost volume and kind of traffic should be considered.

The sum to be expended should be so fixed that the traffic costs will be a minimum.

New One Man Road Grader

A new power grader designed to meet the requirements for city street and county road maintenance work, and also finishing work and light grading for contractors, has been brought out by Wehr Co., 533 30th St, Milwaukee, Wis. The machine utilizes the standard Fordson tractor as its power unit. The grader is constructed of heavy steel channel frame and is put out with either a 6 ft. or 8 ft. blade. The 6 ft. blade is for finishing work and grading and the 8 ft. blade for maintenance work. The blade can be raised or lowered and tilted back at any angle desired by the operator. The tractor is simply controlled by the operator and can be handled quickly and readily by the operator on the tractor seat. The motor is swung on a three-point suspension so that no unnecessary strains are put on the power unit. Scarifier arrangement will be furnished as regular equipment and screws which operate the raising and lowering of the blade will operate the scarifier also. The regular standard Fordson tractor wheels can be utilized, but it is stated any rubber tire wheel equipment can be utilized for highway or city street maintenance work.

Wehr Power Grader.

Straight Edge for Checking Concrete Surface.—One contractor has a 10 ft. straight wooden handle for checking the surface of the concrete before the initial set has taken place. If irregularities are thus formed, they can be easily remedied while the concrete is still workable.

Methods and Cost of Constructing Experimental Earth Road Near Champaign, Ill.

In the interest of better earth road construction and maintenance and for the benefit of road officials in the State of Illinois and elsewhere, the School of Civil Engineering, University of Illinois, this summer undertook to build a model earth highway and after construction, to determine by a number of tests, the best method of oiling and maintaining such roads. The road, which is 12 miles in length, runs north from what is known as Five Points which is about 2 miles northwest of Champaign, Ill., on the Bloomington Road. The entire project was under the personal direction and supervision of Professor W. M. Wilson of the School of Civil Engineering, Illinois University.

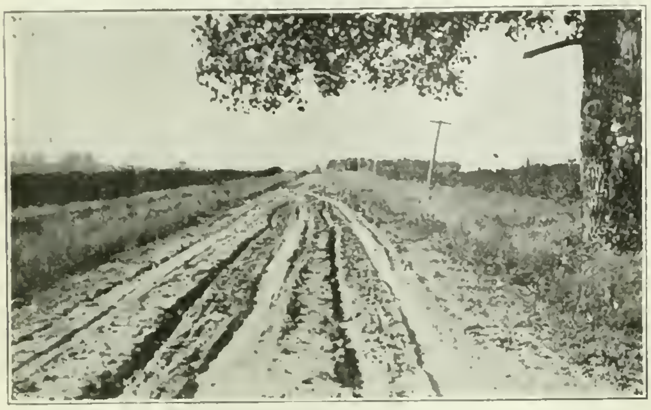


Fig. 1.—Condition of Road When University Began Work.

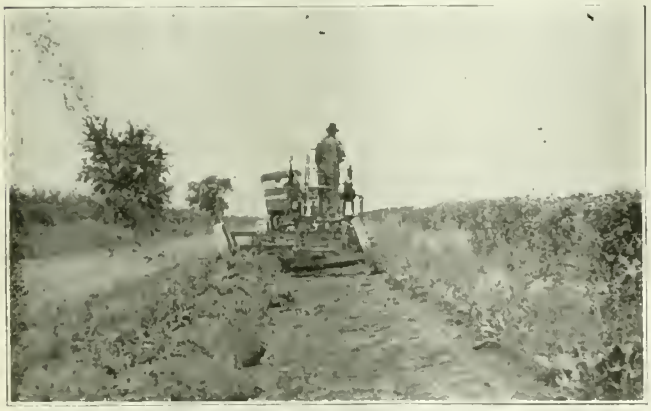


Fig. 2.—First Operation in Grading.

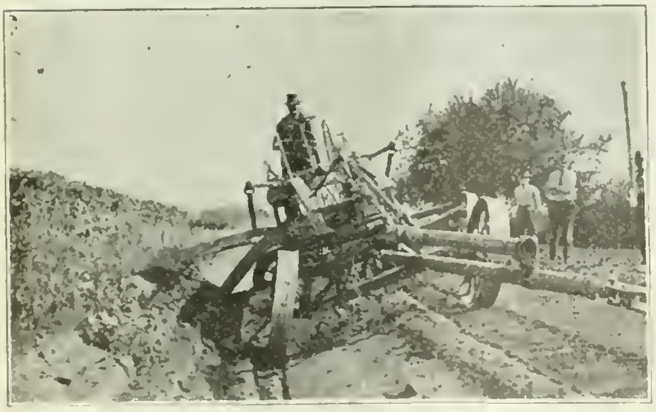


Fig. 3.—Another Step in Grading Showing Back Attachment.

Figure 1 is typical of the condition of the road when the University took it up. It will be noted that the roadway is rather narrow and considerably cut up because of a lack of drainage ditches on the sides. The entire grading was done with an Adams adjustable leaning wheel grader with 12 ft. blade and back sloper attachment and a 10-ton Holt caterpillar tractor.

The first operation, of course, was to stake the ditch lines and then cut all grass and sod off within the lines and place it in the center of the road to be buried. The side ditches were then roughed out by several ditch cuts, the loose earth being used to cover up the sod in the center of the road and the ditches were then finished by putting the back sloper attachment on the grader.

To the hundreds of road officials and contractors throughout Illinois who visited this job while the grading was in progress, one of the most interesting features was the work of this Adams back sloper attachment. By means of this a perfectly uniform back slope, a flat bottom ditch, and the inside slope are cut in one operation. As heretofore explained, the ditch is first roughed out or "stair-stepped" with the grader blade and then the back sloper attachment is put on to make the finishing cut.

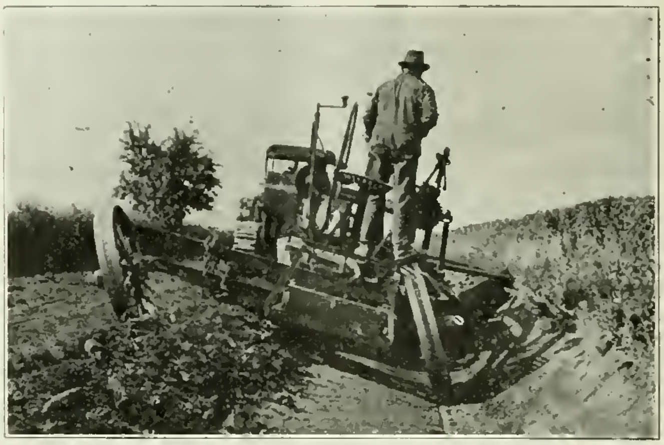


Fig. 4.—Roughing Out Ditch or "Stair Stepping" With Grade Blade

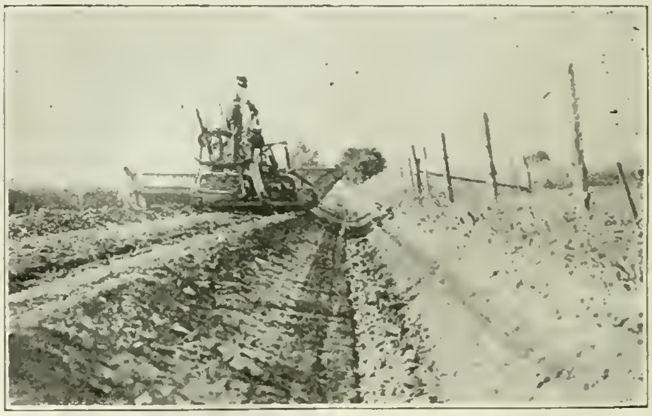


Fig. 5.—Finished Ditch with Grader Finishing Shoulder.

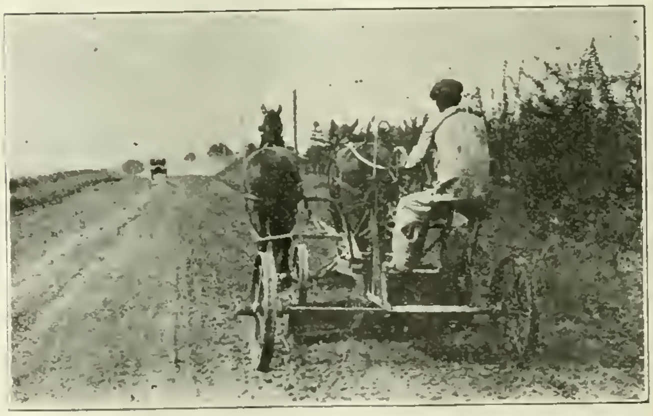


Fig. 6.—Completed Road Under Patrol Maintenance.

The advantages of a back-sloped and flat bottom ditch have long been recognized by highway engineers and state highway departments. As ditches on county and township highways used to be built with the bank left perpendicular it was only a question of a short time until the bank caved into the ditch and filled it up again. Back-sloping the bank as well as putting a flat bottom to the ditch forestalls this action

TABLE 1.—COST DATA ON EXPERIMENTAL ROAD—UNIVERSITY OF ILLINOIS.

Machinery Investment.		
Tractor	$6,000.00	
Grader with attachments	1,600.00	
Total	$7,600.00	
Depreciation per year at 20%		$1,520.00
Interest per year at 6%		456.00
Repairs per year at 4% (estimated)		304.00
Total annual cost		$2,280.00
Cost per day (based on 120 days operation per year)		$19.00
Daily Operating Cost.		
Machinery		$19.00
Labor (grader operator, tractor operator and one helper)		15.00
Gas, 29.4 gal. at 23.2 ct.		6.83
Engine oil, 2 gal. at $1.00		2.00
Track oil, 2.55 gal. at 30 ct.		.76
Grease, 1.82 lb. at 20 ct.		.36
		$43.95
Supervision 15%		6.55
		$50.50
Cost of Grading Typical Mile.		
Grading time including care of machinery, 2½ days (at 8 hours per day) at $50.50 per day		$125.25
Earth moved (measured in cut), cu. yds.		2,474
Cost per cubic yard ($125.25 divided by 2,474)		$0.051

and makes such ditches last at least twice as long as ordinary ditches, as well as giving them greater water capacity.

Figure 5 shows a finished ditch with the grader finishing the shoulder. Figure 6 illustrates the re-graded road shortly after completion.

A practice adopted on this road which road officials everywhere would do well to adopt, was the practice to put on a maintenance machine as soon as the grader left the road. The road patrol shown in Figure 6 constantly patrols the newly graded road, breaking the clods and eliminating the formation of ruts while traffic and the elements harden the surface. The result is a perfectly smooth surface which hardens almost to the consistency of concrete. The road is kept in that same condition by the more or less constant patrolling with this little machine shown in Fig. 6, which has been assigned to the maintenance of the job.

The grading costs in Table I are figures given out by the University. It will be noted that these figures include all costs including interest on investment, depreciation, repairs, supervision, etc. While the yardage cost is low it should be explained in connection with the use of these figures that allowance is to be made for time lost in interruptions by visitors to ask questions.

Oiling experiments to determine the most suitable oil for road work and the most practicable methods of applying it are now in progress on the road and will be for several months. The University of Illinois is particularly anxious to have as many highway officials and road contractors visit this job as possible, where they can see and have explained to them the construction of the road and the oiling experiments now being carried on, and thus reap the benefit of the University's efforts in their behalf. A complete printed and illustrated book on this research work by the University is now being prepared and will be sent free of charge to all road officials and contractors requesting it. Applications should be addressed to Professor W. M. Wilson, School of Civil Engineering, University of Illinois, Urbana, Ill.

Qualifications of Bidders on Kentucky Highway Work

The State Highway Department of Kentucky now requires that each contractor submitting a bid at its lettings shall also submit a statement which will bring out his financial standing and his past record. The conditions are summarized as follows in the following announcement of Jos. S. Boggs, State Highway Engineer of Kentucky:

"The laws of Kentucky give to the State Highway Commission the right to reject any or all bids at a contract letting, and require them in making an award to select the lowest and best bidder, the attention of all bidders being called to this in the advertisements of lettings to be held.

"For the past year, in addition to this, bidders whose work is unknown to the Department have been required to file with their proposals a verified and sworn financial statement, a list of equipment, banking reference, and recommendations from those for whom they have formerly performed work. At some of the lettings held in recent months a few of the low bids have been rejected on account of a noncompliance with these provisions of the advertisement and award made to the contractor that the Commission considered the best experienced and the most responsible. Contractors who have had their bids rejected for these reasons have sometimes seen fit to direct a great deal of censure against the officials of the Department and have felt that they have been mistreated in the matter of award and that preference was being given to other contractors over them.

"In defense of this policy of the Commission it is well at this time to state that because an individual or firm is low bidder on a contract at the time of letting it is no evidence that at the completion of contract they have been the best bidder. The Commission owes it to the public in its selection of contractors to make its award to those that will give the highest type of service, that will inconvenience the traveling public the shortest period of time, and that will carry on the work with the least amount of engineering supervision.

"In order, however, that in the future there will be no further confusion in regard to the furnishing of financial statements, lists of equipment, and experience records, there will be attached to each proposed a questionnaire which, when properly answered, will bring out not only the financial standing of the bidder but his past record as well. Any bidder not filling out this questionnaire will have his bid disqualified just the same as if he had failed to properly fill out the items embraced in the proposal.

"When it is shown that a bidder is not qualified to perform the work he is bidding on or has not sufficient funds to properly finance a project he will not be awarded a contract, and no apology will be made to him for the rejection of his bid. The public is entitled to the best service for the money that it invests in highway construction, and such service must not be impaired by the selection of contractors not capable of properly executing the work entrusted to them."

New Dump Body for 1-Ton Trucks

A new dump body for Ford 1-ton trucks has been placed on the market by the Griscom-Russell Co., 90 West St., New York. A distinctive feature of this body is the scale balance support, the body dumping automatically upon releasing of the locking device. The driver can operate the dump body from the driver's seat without stopping the truck. The dumping operation is as follows: The driver releases locking device and body automatically tilts until it reaches the 45° angle, at which time the tail gate automatically opens and the load dumps. This tail gate can be arranged to spread material to any desired thickness on the road. The gate is of the double acting design, permitting change to express body. The scale balance support is about 5 ins. in front of the rear axle giving a very superior distribution of the load on the chassis.

Jiffy Dump Body.

Tree Planting Along Highways in Minnesota.—The Forestry Department of Minnesota plans to set out 30,000 trees along highways this year.

A Census of Highway Research

Report of Advisory Board on Highway Research of the National Research Council

Beginning March 1, 1922, requests for information have been sent out by the Advisory Board to all the colleges and universities considered as possibly conducting highway research, and to the state highway commissions and other official highway departments. A partially complete list of municipalities, state geologists and industrial laboratories was also used. No attempt was made to obtain a census of research in the motor vehicle field, this being a project of Dr. H. C. Dickinson of the Society of Automotive Engineers.

(1) PERSONAL REPORT.

	No. of questions sent.	Replies			
		Total.		Research conducted.	
		No.	Pct.	No.	Pct.
Colleges and universities..	274	130	47.5	58	44.6
Industrial laboratories	47	18	38.6	11	61.1
Municipalities	115	34	29.5	12	35.3
Official Highway Depts....	124	65	52.4	41	63.1
State geologists	35	22	63.0	16	72.4
Total	595	269	48.7	138	51.3

(2) ORGANIZATION REPORT.

	No. of questions sent.	Replies			
		Total.		Research conducted.	
		No.	Pct.	No.	Pct.
Colleges and universities..	131	85	65.0	43	50.5
Industrial laboratories ...	48	19	39.6	11	58.0
Municipalities	115	34	29.5	12	35.3
Official Highway Depts. ..	51	42	82.4	33	78.7
State geologists	35	22	63.0	16	72.9
Total	380	202	52.7	115	57.0

(3) PROJECT REPORT.

NUMBER OF INDIVIDUAL RESEARCH PROJECTS IN HIGHWAY ENGINEERING AND HIGHWAY TRANSPORT.

	Economics.	Operation.	Design (road).	Construction.	Materials.	Total.
Colleges and universities....	17	3	47	12	127	206
Industrial	1	1	3	0	19	24
Municipalities	5	1	6	1	18	31
State highway departments.	13	2	25	8	101	149
State geologists	0	0	3	0	17	20
Total	36	7	84	21	282	430

On June 28 a tabulation was made of answers so far received by the Advisory Board from the original questionnaire and a follow-up letter. Three tables were made (1) the personal report; (2) the organization report; and (3) the project report; showing the returns from all the questionnaires sent out. The personal report includes all individuals circularized to the number of 595. For example, in one college several professors might be conducting research, and each was sent a questionnaire. The organization report shows the number of organizations which received questionnaires to the number of 380. The project report includes the analysis of the researches as to field of application. The data includes a description of the project, methods of attack and names of research workers.

The number of replies received will be increased by a second follow-up letter. About half of the individuals replying are conducting research. Of the 131 colleges and universities addressed, 65 per cent replied, and of these 50.5 per cent are conducting research useful in the highway field. Of the 51 official highway organizations addressed, 82 per cent replied, and 78.7 per cent of these are conducting research.

The Advisory Board has divided the various projects in highway research into five classes: Economics; operation; design of road; construction; and materials. From the data so far received, it appears in the project report that the colleges and universities are conducting the greatest number of projects, and the state highway departments next, 206 and 149 projects respectively. As might be expected, the subject of materials is receiving the most attention, partly because of the ease with which such tests are made, and partly because other fields have only recently come to be occupied. Approximately 65 per cent of the projects is devoted to materials; 19 per cent to the design of road; 9 per cent to economics; 5 per cent to construction; and 2 per cent to operation. Several organizations active in highway research have not replied.

Distribution was found to be fairly widespread, with the exception of a group of states in the South and in the Southwest, which do not appear to be conducting research.

It is evident that a large amount of highway research is being conducted, and it is now the task of the Director of the Advisory Board to publish and send out to all the organizations a summary of the researches which are recorded at the Research Council, thus putting the workers in touch with each other and stimulating the efforts of others. Cases can be cited in which one state has been saved the delay and cost of an investigation relative to the use of materials, when informed of the completed investigation available from another state.

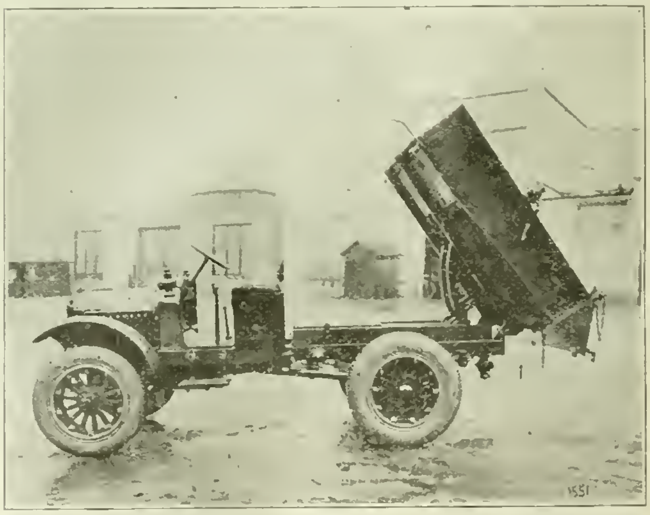
A bulletin will be issued shortly containing a tabulated statement of the nature of the individual projects, classified in various ways.

The value of the information supplied upon these requests is demonstrated by the fact that it has already been possible to refer persons seeking information to definite sources from which accurate information may be secured. Of 109 requests for information on various subjects received from State highway departments, universities, cities, geologists and industries, it has been possible to answer 56 by reference to the investigators who have valuable information to give.

The range of subjects covered by these requests for information includes highway materials, methods of testing, economics, drainage, surfacing, subsoils and others. Fifty-nine per cent of the requests relate to materials, methods of testing and subsoils.

A New Short Base Truck for Road Work

A new short wheel base truck, equipped with 1 and 2 cu. yd. batch bodies, especially designed for road building, has been brought out by the Republic Truck Sales Corporation, Alma, Mich. The chassis has a wheelbase of 110 ins. with a turning radius of 15½ ft., and is equipped with pneumatic tires. The carburetor is equipped with a special air cleaner to prevent dust and grit from being carried into the engine cylinders. A vacuum gasoline system assures steady flow of fuel to the last drop, and a special low gear ratio enables the truck to negotiate sand and mud roads without difficulty. The body is mounted comparatively low to the ground, and is well balanced over the rear axle, with approximately 40 per cent of the total load carried on the front wheels. Three body designs adaptable to the various methods of construction in use by road contractors have been worked out, all of 2 cu. yd. capacity. The standard rear discharge type is fitted with an under-body hydraulic hoist, and is fitted with a center, swinging partition controlled by the driver. This body is intended for use in connection with a central proportioning plant. For the wet mix system, a different type of body is furnished with the Republic road builder. This body comprises two gravity end dump hoppers, each having a capacity of 1 cu. yd., and designed especially to handle a wet mixture. Each hopper may be dumped instantaneously by the driver without leaving his seat. By pulling a lever the hopper is released and the weight of the load automatically dumps the body which is built on a radius with the center of gravity being the pivot center. After the load is dumped the hopper is tipped back by hand and



Republic Road Builder with Horizontal Underbody, Hydraulic Hoist.

automatically locks itself. A third body option provides for mounting two batch boxes of 1 cu. yard capacity so that contractors may use existing equipment if preferred.

Oiling Dirt Roads in Jackson County, Missouri

Results of Several Years Experiences, Outlined in Paper Presented at 1922 Convention of the Missouri Highway Engineers' Association

By LEO E. KOEHLER,
County Surveyor and Highway Engineer of Jackson County.

The use of oil on our dirt roads is saving the farmer many times their cost in transporting his products to market, to say nothing of the pleasure of driving over good roads. It encourages the farmer to trim up and otherwise improve his farm—adds to the beauty of the country and to the value of the land.

In Jackson County we have been using oil on dirt roads for several years, with more or less success; as we have studied and experimented we find a great and varied difference in road oils. The first oil, "I am reliably informed," in use here was from 24 to 30 Baume gravity, no mention of asphaltic contents being made. That oil was beneficial as it laid the dust and somewhat shed the water, but being of a light volatile substance it soon evaporated and it was found that the greatest good from that class of oil was obtained by saturating the road in the late fall and this did help to keep the farmer out of the mud during the winter.

Later experiences have demonstrated to us that three things are absolutely necessary for the construction of a good oiled dirt road:

First. Road must be put in proper condition to be oiled.

Second. The proper kind of road oil must be used.

Third. Oil must be applied properly and at the proper time.

Preparation of Road for Oiling.—In discussing requirement No. 1, will say that my greatest trouble in the shaping of a road is with inexperienced help as road builders. We are blessed in this county by an antiquated system of road overseers appointed by the county court; very frequently not for their knowledge of road building, but for the reason that they are good vote getters, and have little or no interest in good roads. These esteemed gentlemen, of whom I inherited 59, had previously been instructed that the crowning of the road was the most important factor in the shaping of it, and they proceeded to shape the road like a hip roof, thereby causing all the travel to go to the center, straddling the ridge so as not to skid into the ditch, which they invariably did when it became necessary to pass someone on the road.

The old saying, "It is hard to teach an old dog new tricks," was true in our case, and in spite of all we could do or say, many of our oiled dirt roads are over-crowned, which causes a dangerous condition in slippery weather.

Our idea of the proper shaping of a dirt road for the receiving of oil is as follows:

The road must be thoroughly ditched and all loose material removed from the roadway to be oiled. Always grade the roadway from the center, pushing the loose material to the outside quarters; here is where a good blade machine man is to be appreciated, as a poor man can do more damage with a blade in one day than can be corrected in several days. The surface of the road should be as solid and free from loose earth as it is possible to make it and should be crowned only enough to cause the water to flow to the ditches, and in this connection will say that it is much better to have the road too flat than over-crowned, as on a flat surface the travel is more evenly distributed over the entire surface, thereby causing longer life to the road and more safety to travel. Most roads in this section have a longitudinal grade which will take care of the drainage with a very slight crown. A draw always working from the center towards the side of the road should be used after grading is finished.

The Oil.—It is very essential that oil for dirt roads should be as near non-volatile as possible, should contain not less than 60 to 70 per cent asphalt and as great a percentage of saturation as possible. The method of refining has much to do with the saturation, volatilization and quality; therefore, we deem it highly essential that a chemical analysis of the oil to be used be made before it is applied, as many of the oils offered are nothing more or less than fuel oil, which will not give satisfactory results.

Applying the Oil.—This also is very important and it is here that the man in charge of an oiling crew is of great importance, as it is his judging that will determine the amount to be applied and if the road is in shape to receive the oil, and if weather conditions are such that oil should be applied.

The oil may be applied by either the pressure or gravity feed system. We have adopted the latter on dirt roads on account of the excessive weight of the former, as we found that many of our small bridges and culverts would not carry the weight.

The oiling of hard surfaced roads, we believe, can be done much better by the use of the pressure system as it sprays the oil on much more evenly than can be done by gravity, but on dirt road this is not essential.

One theory of road maintenance is to keep the water out of the subgrade; that theory holds good here. Therefore, a sufficient amount of oil should be applied to form a cushion sufficient for use as a wearing surface, and to seal the surface of the road, thereby making it as nearly waterproof as possible, the exact amount to be applied can be ascertained only by the conditions found on the ground but for general purposes, we should say ½ gal. more or less, per square yard of surface is necessary for the application of one coat. If more than one application is desired, a lighter oil, say one containing 40 to 50 per cent asphalt, can be used first and when thoroughly set a second application of oil of 60 to 70 per cent asphaltum should be used; our experience has been that one coat in the spring and another one in the late fall produces the best results, as it gives additional strength to the road for the hard and damaging traffic of the winter.

Thus, we believe, with a little care the foregoing procedure will produce a good and inexpensive road that will be smooth, dustless, noiseless and with sufficient rigidity to withstand a heavy rural traffic, the maintenance being very low compared to most hard-surfaced roads.

Cost of Road Oiling.—In 1921 there were 237 miles of dirt roads oiled once, 47.5 miles of dirt roads that were oiled twice, 151 miles of rock roads that were oiled once, and 21.5 miles of rock roads oiled twice, making a total mileage of roads oiled of 526. There were 1,679,306 gal. of road oil used at a cost of 6¼ ct or $104,956. The cost of placing of the above given amount of oil was $43,114, or approximately 2½ ct. per gallon.

There was an average of 3,200 gal. of oil used per mile, the cost of which was approximately $200 per mile, the application cost for which was approximately $81 per mile, making a total of $281 per mile. The total cost of road oiling was $148,070.

A New Wrench

A new wrench with several interesting improvements has just been put on the market by the Greenfield Tap & Die Corporation, Greenfield, Mass. This wrench has the "end opening feature;" its application to pipe turning can be seen by a glance at the accompanying illustration. An advantage of this wrench is the ease with which it can handle pipes in corners, close to walls, and similar confined places. The wrench has only three parts; a handle and jaw in one piece, which is drop forged and heat treated; a movable jaw, likewise drop forged and heat treated and a hardened steel nut. There are no springs, rivets, frame or pins. The new wrench has been designed for maximum strength. The 14-in. size is stated to have repeatedly withstood stresses in excess of 4,700 inch pounds without slipping or bending. Another feature is the double set of teeth on the main jaw. The movable jaw can be engaged at the option of the operator with either of these sets of teeth with consequent lengthened life. The wrench is being manufactured in 8, 10, 14, 18 and 24 in. sizes, of which the three smaller sizes are already on the market.

Little Giant Pipe Wrench.

Where Paper Profits Go in Highway Contracting*

It is presupposed by the title that the contractor has been "from Missouri" when preparing his bid, and has given it the intelligence and diligence he expects to put forth in executing the work, if successful, and that all known items of overhead such as officers' salaries, interest on retained percentages and invested capital, bond, cost of preparing estimates, field and office expenses, taxes, and that all direct charges such as freight, setting up and moving plant, depreciation, depletion, repairs and storage on all equipment, public and employes' liability insurance, camp site rental, small tools, etc., have been included as cost before profit is added. Incidentally, Mr. W. O. Winston, past president of the Associated General Contractors, and dean of successful engineering contractors, when asked how much profit should be added, replied, "If you are sure of your cost, add 10 per cent for contingencies and 10 per cent for profit." Repeating that, with the assumption that these items have been included as cost and the desired profit added, the object here will be to show why this paper profit is seldom realized.

Why the Paper Profit is Seldom Realized.—First: Most contracts prepared by engineers are one-sided, and with few exceptions, the interpretation by the author results in loss to the contractor. This condition is being corrected by the work of a joint committee from the American Society of Civil Engineers, and the Associated General Contractors, who are preparing a form of contract.

Second: There is a tendency among resident engineers to under-estimate work done each month, which largely increases the interest on capital needed to carry the job.

Third: The growth of automobile traffic and the consequent injury to highways has been so rapid that engineering practice has not agreed on the best type of roads and methods of construction; consequently, there is no authority to guide inspectors, therefore, each acts from an independent viewpoint with the result that methods learned under one engineer's supervision will not satisfy another.

Fourth: Contractors are necessarily of an optimistic disposition and are inclined to take their cost data from a few days of good work on a previous job rather than an average yearly cost, and the principle reason for disappointment is this tendency; to particularize:

Highway Grading Expensive.—The first item of building a highway is, of course, the excavation. In many states this includes clearing and grubbing, removing structures (which may be a fine residence), fences, telephone poles, etc., and while it is seldom done carefully, the cost of these items may be estimated with reasonable accuracy, but most contractors, basing their cost data from experience gained in railroad grading, overlook them and also fail to realize that the small amount of material to be handled per mile; the accuracy of the surface required; the necessity for thoroughly compacting the embankment; the cost of preparing shoulders after the surface is applied, months later when rains may have washed away much of the material intended for that use, make highway grading an entirely different matter and vastly more expensive problem than railroad grading, but with the same risk of finding good or bad material. Grading costs often vary 100 to 200 per cent above a carefully prepared estimate. Mr. Thomas H. McDonald, Chief of the United States Bureau of Public Roads, after an analysis of excavation costs over the entire country says, "The man who attempts to forecast the cost of excavation from a knowledge of previous cost, is a most intrepid individual."

Surfacing.—If this is done with gravel, and the contractor is paid by the cubic yard, loose, or by weight, the problem is simply one of locating suitable pits, selecting efficient loading and transporting equipment, allowing for bad days and break-down of equipment, spreading and rolling, but where he is paid for a certain thickness after compacting, he faces the impossible task of estimating the amount of loose material required, because different materials compress to a different extent, some require 25 per cent excess, others 50 per cent. The same uncertainty applies to the application of crushed stone and in all classes of highway construction the quantities handled are so large, that a very slight error in judgment runs up into a large total.

Telford Base.—With hand-placed base, added difficulties are encountered, as the location and operation of stone quarries are necessary. This is similar to any other mining operation, and it is well known that mining is a hazardous industry; even in gold mines, it is estimated that more money has been sunk into them than has been taken out. The quarries must be located within a reasonable distance of the road and at the proper distances apart, with light overburden; the stone must be suitable and easily worked; semi-skilled labor is required and efficient equipment necessary. No experience can positively locate a quarry answering the above requirements; and it is frequently found that stone passing the French test will disintegrate after a few months in the weather; other stone that will pass the test cannot be drilled or sledged; stone that is suitable in one part of the quarry, may entirely disappear on account of a geological fault and the remainder be worthless; these conditions may easily cause a variation in the cost of 100 per cent, which on ten miles of penetration roads with stone base may amount to $20,000.

Lost Time Due to Bad Weather.—Where the material is delivered on cars, the chief cause of uncertainty and consequent loss is due to shortage of railroad equipment, indifferent service by the railroads in handling a commodity at a low freight rate, and the cost of well located team tracks. The above may easily use up Mr. Winston's 10 per cent for contingencies, but there is another cause affecting highway work more than any other and that is the cost due to lost time on account of bad weather, where the material must be hauled over soft roads. After every shower the roads are too soft for trucks or too slick for the roller, for several days, and in cold weather asphalt and concrete cannot be placed. On such a contract we only worked 87 days between July 4 and Dec. 31, 1921, while on a similar job, over hard roads during the same period, we worked 142 days.

The State Highway Department of Iowa reports that an average of 31 contractors, in its state, could have completed the 1921 season's work in 114.3 calendar days had there been no delay. Consider the waste and how the profits disappear when a contractor estimates his rental cost on a use of 250 days in the year and only gets 114.

Loss From Idle Equipment.—For example, a properly equipped and well-organized road job, 10 miles long, surfaced with an 8-in. modified Telford base and a 2½ in. asphalt penetration coat, costing $200,000, will require one year for the grading and one year for the surfacing. The equipment for the grading will be 50 mules, 6 dump carts, 10 dump wagons, 16 wheel scrapers, 5 drag scrapers, 1 stump puller and 1 pumping outfit. The daily rental of this outfit, according to the rental schedule prepared by the Associated General Contractors, considering the livestock at $1 per head, will be $58; the time of the superintendent, timekeeper, and steady-pay men will be $23 per day; the overhead will be not less than $4 per day, making a total of $82 for each day, including Sunday, that the equipment is idle.

For the base and surface, there will be required 2 tractors, 2 graders, 3 10-ton rollers, 2 portable crushing outfits, 4 quarry outfits, 1 oil distributor (with tank and boiler), 8 3½-ton trucks, 1 1-ton truck, 1 passenger car, the rental of which will amount to $60 per calendar day; add for the steady-pay men $23 per day and $12 for overhead, which makes a total of $95 per day; therefore, if only 180 days are worked on the grading in a year the contractor's loss is $15,150, and if only 150 days are worked on the surface the contractor's loss is $20,425, which is 17½ per cent of the total cost of a job of this size.

The last item is undoubtedly the largest cause of loss, and, like the other causes, it can only be determined from records carefully kept on previous jobs. Paper profit will not stay at home until bids are made from data obtained from an entire year's performance, eliminating the false hope that weather or other adverse conditions will change.

Rains Interfere With Pennsylvania Highway Construction.—Operations of the Pennsylvania Highway Department during 1922 have been interfered with by the unseasonable rains, which in their frequency have rivaled the rains which interrupted the Department's work during the forepart of the Summer of 1919. The U. S. Weather Bureau reports that during the 82 days of May, June and July, this year, there has been rain on 34 days.

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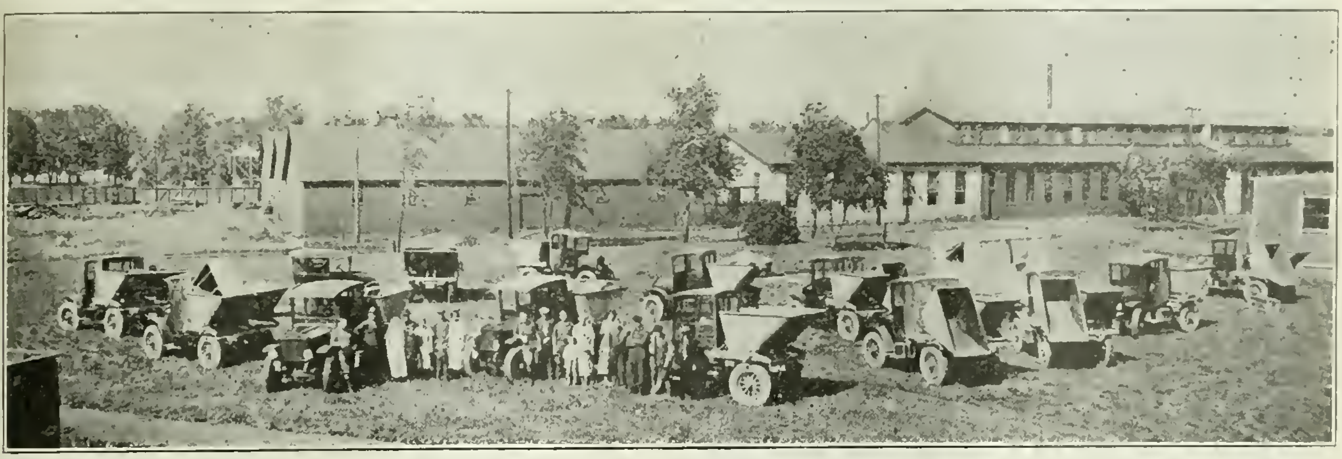
*From Tennessee Highways.

Commercial Motor Truck Haulage for Road Contractors

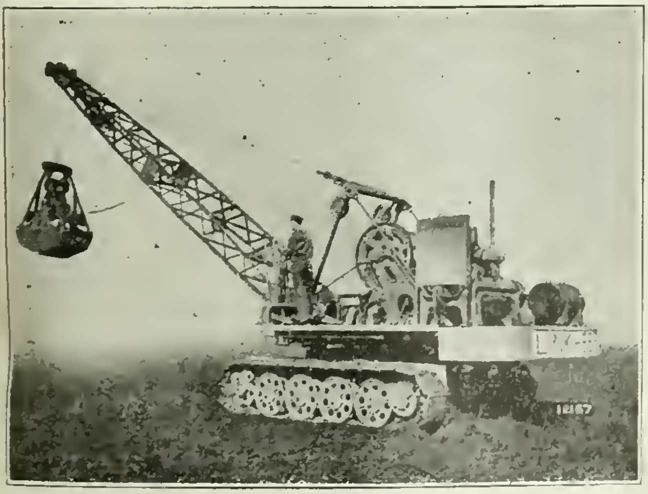
In the last two or three years a number of motor truck haulage companies have specialized in hauling for contractors engaged in highway construction. The accompanying illustration shows a part of the fleet of the Commercial Trucking Co. of Detroit, Mich., on the grounds of The Heil Co., Milwaukee, where the trucks had been driven for the installation of Heil dual gravity bodies. The Commercial Trucking Co. was very anxious to get its units in a hurry and as their contract for road work was secured in Wisconsin, the trucks were driven to Milwaukee for installing the units. The trucks shown are 1½-ton, 105 in. wheelbase Selden, and each carry two 1 yd. gravity bodies. The trucks are tractor units, so the bodies can be removed and the trucks used for hauling trailers in the winter. The bodies are the standard Heil type. The Commercial Trucking Co. of Detroit, of which Mr. R. J. Handy is president, is now operating 25 Selden units, Mr. H. D. Fairchild is manager of the fleet that came to Milwaukee. Eight of the trucks go to Brandon, Wis., and the other five to Waukesha, Wis., both working for the Badger Contracting Co. After the first six weeks the trucks will be assembled at Beaver Dam, Wis., where they will work on one job the rest of the season. The party included a number of families of the drivers and wherever they stop a camp is put up where they establish their headquarters. This arrangement seems to be much more satisfactory to all concerned.



Part of Fleet of the Commercial Trucking Co.

New Crawler Crane

A new crawler crane having a number of distinctive features has been brought out by the Link Belt Co., Chicago. The crane weighs complete without bucket approximately 22 tons, making a ground pressure of 10 lb. per square inch with its size of caterpillar treads. It is stated it will safely lift 10 tons at 12-ft. radius, and 3 tons at 30-ft. radius. The hoisting speed is 125 ft. per minute with a maximum rope pull of 10,000 lb. on a single line. Having two independent band-clutch-operated hoisting drums, the standard machine is suitable both for clam-shell and dragline bucket work. The crane will rotate four complete revolutions per minute, travel ¾ mile per hour, and climb a 20 per cent grade. The shoes are 18 in. wide, 12 in. pitch, one-piece high carbon chrome steel castings, with machined holes for 1¾ in. diameter high carbon pins. There are eight bronze-bushed crawler rollers, 25 in. in diameter. The over-all width of crawler tread is 9 ft. 7 in., while the center to center of sprockets lengthway is 10 ft., giving a bearing area of 30 sq. ft. The lower frame is a single annealed open hearth steel casting, designed with ample factor of safety to carry all the various severe diagonal stresses a machine of this character is undergoing. The rear axle is in distinct Link Belt design, and is a hollow cast steel dead axle housing, similar to automobile practice, on which the load carrying sprockets are mounted, and inside of which are the floating drive axles, with cut bevel gearing, running in a bath of oil. The control clutch, steering the caterpillar, is also located inside this housing. This clutch is in constant connection with a foot lever on the operator's platform, and can be used in any position of the rotating base. The gasoline engine power unit is a Climax Engineering Co. 4-cylinder, 5½ x 7 in. heavy duty tractor engine running 800 revolutions, and is equipped with an automatic governor, gear driven fan, centrifugal water pump, and force feed lubrication to all bearings, also an Eiseman high tension magneto with impulse starter. The radiator is extra large standard tractor type. The gasoline tank is of 30 gal. capacity and holds enough gasoline for about 15 hours' continuous running.



Link-Belt Crawler Crane With Housing Removed to Show Mechanism.

The New President of the American Road Builders' Association

Thomas J. Wasser, who was recently elected president of the American Road Builders Association, has had an experience of 32 years in general construction, railroad and highway work. He was born in Philadelphia in 1871 and at the age of 21 began work on macadam highway construction with B. M. and J. F. Shanley, general contractors, of Newark, N. J. During the next few years he served with the Long Island R. R., with the Consolidated Traction Co. of Jersey City, and with the Sanford & Stillman Co., general contractors and bridge builders of Jersey City, acting with the latter organization as foreman in charge of building the Harlem transport freight yards at 135th St., New York City, piers for the Lehigh Valley R. R. at Jersey City, and buildings for the United Gas Improvement Co.'s plant at East Chester, N. Y.

Beginning in 1899 he spent four years with Robert W. Hunt & Co., engineers, New York, on mill, shop, and erection inspection, and in 1903 was appointed by James Owen, Essex County Engineer, and J. W. Leahy, Hudson County Engineer, to assume charge of preliminary work for the Hackensack bridge and Newark plank road, and later was placed in charge of this construction. Mr. Wasser also directed the construction of the 14th St. viaduct in Hoboken.

Mr. Wasser became engineer of Hudson County in 1913, and designed and constructed most of the Newark turnpike. Resigning that position in 1920 he was selected by the reorganized state highway commission to be state highway engineer of New Jersey. In addition to membership in a number of the national engineering societies, he is president of the New Jersey Board of Professional Engineers and Surveyors.

Thomas J. Wasser, State Highway Engineer of New Jersey.

Portable Power Drag Scraper Rig

To meet the requirements of the man who is handling material in a small way, especially the county road commissioner or contractor, who wishes to utilize a local sand and gravel deposit, a new type of portable power drag scraper outfit has been placed on the market by Sauerman Bros., 322 S. Dearborn St., Chicago.

The new outfits are equipped with "Crescent" type power scrapers, which are especially suited for use with a light power unit as they are easy to pull and travel straight. The double drum hoist is furnished with gasoline engine direct connected or is arranged for belt drive from tractor or other motive power. The truck frame is of heavy steel channel construction mounted on broad tread, grooved steel wheels with steel axles.

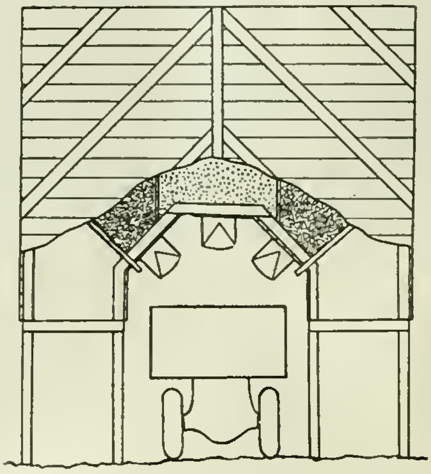
Sauerman Portable Drag Scraper Hoist.

Any laborer on the job can operate a Sauerman portable scraper outfit. Two levers, side by side, control the entire operation. No pit-man is required as the scraper is self-loading and self-dumping.

It is stated the entire outfit can be made ready to move in a jiffy and in less than an hour after arriving at new location it can be in operation. In moving from one set-up to another, simply wind the cables on the drums, disconnect the bridle cable, put the scraper and blocks on the truck, hook on the tractor, motor truck or team, and pull out. At new location sink the wheels of the power unit into the ground, connect bridle cable to new stakes or deadmen, locate guide blocks, haul out the cables, hook onto scraper bucket, turn over the engine and go.

Handy Gate System for Crushed Rock Bin

A bin arrangement which permits the loading of three sizes of stone separately, or a mixture of any two or all three sizes, with a motor truck in one position, is used at the quarry on the Ernest Flagg estate, Staten Island, N. Y. The bin is built in three compartments as illustrated in the accompanying sketch, which is reproduced from Rock Products. The crushing plant is designed to produce about 250 tons of crushed stone per day.



Sketch Showing Gates and Bin Arrangement.

Personals

Boyd A. Bennett, heretofore director of public works at Lynchburg, Va., has been appointed city manager of Charlottesville, Va.

The Associated Engineers, Inc., engineers, constructors and managers, on or about Aug. 1 will move to larger quarters at 373 Broadway, Milwaukee, Wis.

J. A. L. Waddell, consulting engineer, New York and Kansas City, Mo., has been elected a member of the Royal Academy of Sciences and Arts of Barcelona, Spain (Real Academia de Ciencias y Artes).

Walter Moore, Jr., has resigned his position as manager of the Southern California Chapter, Associated General Contractors of America, to accept the sales management of the Union Rock Co. of Los Angeles. E. Earl Glass, engineer for the chapter, is now manager. The Southern California Chapter maintains a suite of offices and a paid staff of assistants to assure prompt and efficient handling of the A. G. C. activities in that district.

Industrial Notes

Robert W. Appleton, production engineer of the Pierce-Arrow Motor Car Co., of Buffalo, N. Y., has been appointed manager of purchases of the company. Mr. Appleton will also continue his duties as production engineer. He has been identified with the Pierce-Arrow factory for more than 20 years.

A. A. Murphy has been appointed resident sales manager of the industrial and railway paint and varnish division of the du Pont Company, with headquarters in New York City. He will be located at the new office the paint and varnish division has opened at 30 Church street. Mr. Murphy has been with the du Pont Company for many years.

The Kelley Island Lime & Transport Co., the world's largest producer of lime, at its recent directors' meeting, following the annual stockholders' meeting, elected the following officials: John A. Kling, chairman of the board; George R. Johnson, of Buffalo, who has been vice-president of the Foundation Co. in charge of its central district for 14 years, president; F. W. Ohlemacher, who was elected fourth vice-president, has been in charge of the company's vessels and Sandusky department for many years. Following is a list of officers and the executive committee: Chairman of the board, John A. Kling; president, George R. Johnson; first vice-president, E. W. Oglebay; second vice-president, F. A. Beckwith; third vice-president and general manager, G. J. Whelan; fourth vice-president, F. W. Ohlemacher; secretary and treasurer, C. A. McMorris; assistant general manager, A. B. Mack; assistant secretary and assistant treasurer, F. W. Kuhl; auditor, J. W. Longdon. Executive committee: John A. Kling, chairman; George R. Johnson, H. M. Hanna, Jr., John Sherwin, John E. Morley, H. G. Dalton. Other officers are: Sales manager, Henry Angel; assistant sales manager, F. M. Pinnegar; purchasing agent, Victor Price; traffic manager, J. F. Potts.

Waterworks and Hydraulics Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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E. & C. Index Furnished Only on Request

The index for Vol. LVII—January-June, 1922—issues of Engineering and Contracting will be ready for distribution shortly. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Some Fantastic Arguments in Favor of the St. Lawrence Ship Canal

A ship canal down the St. Lawrence to Montreal will cost about $250,000,000. The report of the engineers on this project indicates that it will be profitable; but some friends of the project are making claims for its profitableness that are extremely fantastic. Thus a recent report by the Illinois Deep Waterway Commission estimates that the annual gain to the farmers after the building of the St. Lawrence canal will be $256,000,000 ,which, if true, would yield an annual profit of 100 per cent on the cost of the canal! This absurd estimate is arrived at by multiplying the entire number of bushels of grain produced in the central states (3,664,000,000 bu.) by an estimated saving of 7 ct. per bu. in transportation.

In a recent Water Ways Number the Chicago Evening Post makes estimates of savings to be effected by the St. Lawrence canal that are almost as fantastic as those above given. The "Post" estimates that the 16 states that would ship grain via this canal produce 3,000,000,000 bu. annually. The "Post" states that the present freight rates for the 1,000-mile boat haul from Chicago to Buffalo is 2 ct. per bu., and that another cent would cover the transportation cost through the canalized river to Montreal. The present rate by lake steamer to Buffalo and thence by large canal boat to New York is 8.5 ct. per bu. By some unexplained method the "Post" arrives at the conclusion that the 3,000,000,000 bu. should be multiplied by the entire 8.5 ct. to get the annual profit from the canal; but, to be conservative, the "Post" says: "If we calculate that the full measure of saving would not be reflected to the farm, but that the farm position will be improved by 4 ct. a bushel, we make a saving in the American farm income of $120,000,000 on a single year's crop." What the "Post" means to say is not that there will be a "saving" in the farm income, but an increase in the farm income of $120,000,000.

If so, the most natural question in the world is why should not the farmers of the 16 states thus benefited pay for the entire canal? They would scarcely claim that the burden of an investment of $250,000,000 would be too great, since the investment would yield an annual profit of 50 per cent.

It is not easy to follow the hazy reasoning by which such enormous profits are to be derived from the St. Lawrence canal. But as nearly as we can trace the reasoning, it appears to be as follows: The price of grain is fixed in Europe by the action the forces of supply and demand operating on the surplus grain exported to Europe from all parts of the world. Since transportation by the St. Lawrence canal will be 5.5 ct. cheaper per bu. than it is at present, the price at the average American farm in the 16 central states will be 5.5 ct. higher after the canal is finished than before. Perhaps this entire gain in price will not be realized by the farmers, so let us call that gain 4 ct. per bu., and multiply it by the entire 3,000,000,000 bu.

This reasoning is grossly sophistical. To begin with, the interest charges and cost of operating the $250,000,000 canal should be deducted from the annual saving in transportation. In the second place, the saving in transportation cost should not be applied to the entire 3,000,000,000 bu., but only to the number of bushels exported. Normally only 5 per cent of our grain crop is exported, or, say, 150,000,000 bu. are exported from the 16 central states. It is probable that a somewhat greater volume of grain exports would occur after building the canal, but only in the event that American grain exporters were to lower the price enough to decrease some of the present exports from other countries to Europe.

The price of wheat is not "fixed" by the surplusses exported to Europe, but by the entire demand as applied to the entire supply. It is an illusion to see in the markets of Europe the sole price making power with reference to wheat. It is even a more evident illusion as to corn, for while 17 per cent of our wheat is normally exported, only 2 per cent of our corn is normally exported. Does this 2 per cent of corn exports, taken together with the even more meager corn exports of other nations, "fix" the price of the 98 per cent that is not exported? If so, it is not the tail that wags the dog, but the flea on the end of the hair on the end of the tail. The fact is that no such fantastic economic law exists as the alleged law that supply of and demand for exported surplusses alone determine prices of unexported products.

Can Lighter Cast Iron Pipe Be Used?

Have cities and companies been laying cast iron pipe of greater thickness than is necessary? C. E. Inman of the Warren (O.) Water Department, says yes. His experience as a superintendent in several cities, dating back 37 years, has led him to this conclusion. He has found that in one city Class A pipe has stood a pressure of as high as 120 lb. per square inch every day for 25 years without a single failure. In several different cities he has tested new installations of Class A pipe with a pressure of 150 lb. without any failures.

It may be seriously asked whether engineers have not been uneconomically safe in specifying Class B pipe for pressures between 65 and 108 lb. To avoid the possibility of a break in the pipe, has not an unnecessary amount of cast iron been used? Even an occasional break is not ordinarily an expensive matter, and it may be better business to have such a break once in a while than to make an entire pipe system 10 to 20 per cent heavier than would be necessary were an occasional break not regarded with such horror.

But Mr. Inman says that even occasional breaks do not occur where Class A pipe is used under domestic pressures of 60 lb. and fire pressures of double that amount.

In 1909 the waterworks system of Warren, O., was appraised and found to contain 2,000 tons of pipe. Had the next heavier size of pipe been used, there would have been 2,500 tons. The investment saving at $40 a ton is $20,000, the interest on which is $1,000 yearly. If the breaks in the lighter pipe had caused a damage of less than $80 a month, it would have paid to use the lighter pipe; but no breaks have occurred as a result of using the lighter pipe.

Such facts lead to the suggestion that the problem of economic thickness of cast iron pipe has not yet been correctly solved by all users of cast iron pipe.

Cleaning Service Pipes

Service pipes are commonly 1 in. or less in diameter, and therefore easily become so clogged with rust as to reduce water pressure to almost the vanishing point. The common methods of removing the rust are: (1) Force-pump flushing; (2) pumping a wad of tissue paper through into the main; (3) blowing out with compressed air; (4) use of a rod, or a wire, or a steel tape, to scrape out the rust; (5) pumping muriatic acid through, to loosen the rust.

The life of a small diameter service pipe is usually 10 to 30 years, but occasionally a water department reports a life of 50 years. The most common practice seems to be to dig up and remove service pipes that are giving much trouble after 20 years' service.

Altogether too many service pipes are only ½ to ⅝ in. It is questionable whether true economy is secured by using pipe less than an inch in diameter.

A very large percentage of customers' complaints about inadequate water pressure can usually be traced to the fact that their services are partly filled with rust. Long before the life of the pipe is ended, it is frequently removed in order to give satisfactory water pressure.

Two-Thirds of Our Urban Places Have No Waterworks Systems

It is commonly supposed that nearly every village in America has a waterworks system of some sort, but two-thirds of the "incorporated places" have no waterworks. According to the last census there were 2,787 incorporated places having a population of 2,500 or more, and their aggregate population was 54,305,000. There were 12,905 incorporated places having a population of less than 2,500 each, and their total population was 8,969,241. This makes a total of 15,692 incorporated places. There are about 5,000 waterworks systems.

Harry F. Furguson, Chief Sanitary Engineer of the Illinois Department of Public Health, states that only 449 of the 1,111 incorporated communities in Illinois have waterworks systems. He says:

> The size of the community that might well have a public water-supply system cannot be definitely stated. Communities of even a few dwellings, in those areas in Illinois where supplies can be obtained from rock or drift wells at comparatively low cost, might to the advantage of all property owners have public water-supply systems. The installation and operation cost of a single pumping outfit would be less than would be the cost for several private running water supply installations, and this saving would tend to offset the cost of a distribution system and the remaining cost of the distribution system would be cheap fire and health insurance.

He divides the 662 Illinois communities that have no waterworks into 10 groups, as follows:

Population of groups.	No. of places.
5,000 and up	1
3,000 to 5,000	7
2,000 to 3,000	9
1,500 to 2,000	16
1,000 to 1,500	56
750 to 1,000	64
500 to 750	120
400 to 500	91
300 to 400	109
Under 300	189
Total	662

Although the aggregate population of these 662 places is only 387,000 as compared with 4,696,000 served with water, still the number of people in "waterless" municipalities in Illinois is very great. In the United States as a whole the "waterless" number is about 9,000,000.

It is probable that nearly all these people could be economically served by some sort of waterworks systems. If so, fully half a billion dollars should be invested in pipe, pumps and other waterworks plant with which to supply them adequately with pure water.

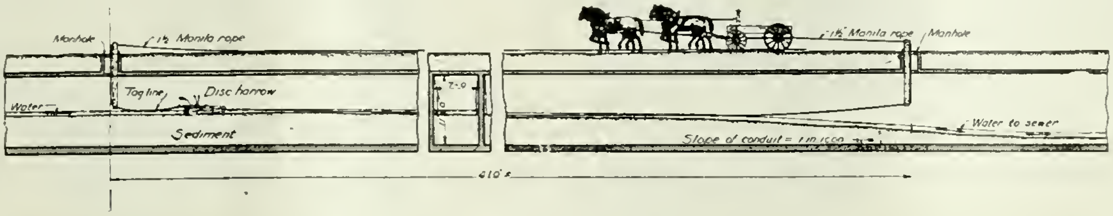
The enlargement and improvement of existing waterworks systems calls for the investment of even more money than to provide new systems for places that now lack systems. Hence fully a billion dollars should be spent for waterworks plants in the near future. Unfortunately, no organized effort is being made to awaken the public to the need of extensive investment in facilities for providing adequate supplies of pure water for every municipality.

Stream Gauging in Indiana.—The average amount of water contained in public streams and rivers in Indiana, together with the effect upon same by pollution and wastes of both industrial and domestic character, is to be determined through a survey started by the engineering division of the state conservation department. To gauge the streams the department will establish a series of stations. The first to be erected will be as follows: On Little Calumet at Gary; Kankakee River at Schneider; on same river at Davis; on Wabash River at Logansport; on same river at Lafayette and at Terre Haute; on west fork of White River at Indianapolis and at Washington, and on west fork of the same river at Shoals and at Seymour. As soon as these stations are installed others will be established on the Wabash River at Huntington, Wabash, Peru, Covington, Vincennes; on west fork of White River at Anderson and at Spencer; on east fork same river at Columbus; on Whitewater at Brookville; on Patoka River at Patoka and at Jasper; Mississinewa River at Peru and Marion; St. Joe River at Mishawaka; Maumee River at Fort Wayne; Wildcat River at Kokomo; Salomie River at Portland, and Blue River at Edinburg.

Method of Cleaning Mixing Conduits at St. Louis Water Purification Plant

A modified disc harrow gave excellent results in cleaning the mixing conduits at the purification plant of the St. Louis waterworks. The recently issued arrival report of Edward E. Wall, Water Commissioner, contains the following account of this work.

The mixing conduits, consisting of four channels, rectangular in section, 7 ft. wide, 11 ft. deep and 2,388 ft. long, have been in service since they were constructed in 1915. The deposit of mud and scale had generally increased in quantity and hardness until in the spring of 1921 a maximum depth of over 5½ ft. was found in the west conduit and 4½ ft. in the one next to it, the other two conduits had about 1½ ft. of softer deposit.



Sketch Showing Method of Cleaning Mixing Conduit.

The two western conduits were taken out of service in May, 1921, and cleaned. About 200 ft. of the north end of the west channel was cleaned by hand, the deposit being so hard as to require a pick to loosen it for shoveling. The material was wheeled to the north end, hoisted and dumped into wagons. About 150 ft. was cleaned by shoveling into a water jet discharging into a settling basin and later on the material was removed from the basin in the usual cleaning process. The remainder of the west channel and all of the adjacent channel was cleaned by flushing while a disc harrow, altered for use in the conduit, was pulled between manholes, located about 420 ft. apart, by means of ropes attached to both ends of the harrow and passing over pulleys set in frames placed in the manholes at each end of the section to be cleaned. Two teams were hitched to the pulling rope and they traveled on top of the conduit in an opposite direction to the movement of the harrow in the conduit. When the harrow reached the end of the section it was turned, the ropes fastened on the opposite ends, the team turned and hitched to the rope which was the tag rope on the previous trip.

This method proved very satisfactory. The discs were truned to suit the kind of material encountered and the water was kept running about 1 ft. deep which swept the material loosened by the harrow into the sewer at the south end. The sections were cleaned in order, from south to north; 3,250 cu. yd. of material were removed, 380 cu. yd. by hand at a cost of $2,199 and 2,870 cu. yd. by flushing and harrowing at a cost of $1,201 for labor and approximately $124 for 10 million gallons of water used in flushing.

Experie[illegible] h Algae at Davenport

An in[illegible] the experiences last year at the Dav[illegible] s, with algae, was given by Mr. [illegible], manager of the water company, in [illegible] of the American Waterworks Association, [illegible] e matter following is taken:

[illegible] July, 1921, the filtered water at the Davenport water[illegible]s was unsatisfactory. The number of bacteria was high and there was more than one positive test for gas formers in five 10-cc. samples tested. Mississippi River is the source of the water; 3.78 grains of alumina per gallon were applied to the raw water, which had a turbidity of 150 parts per million. The water, after treatment with alum, passed through an uncovered concrete settling basin having a sufficient capacity to contain 24 hours flow; 0.74 part per million of chlorine was applied to the settled water before filtration through pressure filters.

Owing to unfavorable conditions the basins had not been cleaned since early spring. On the supposition that the uncleaned basins were the cause of the trouble the basins were cleaned, but without improving the bacteriological conditions of the water. Microscopic examination of the raw water showed vast quantities of algae, "melosira." No tastes or odors accompanied the poor bacteriological condition.

Copper sulphate applied to the water entering the settling basin gave no improvement. There was some clogging of the filter beds but not to a serious extent. As a final remedy the amount of liquid chlorine was increased. To do this it was necessary to increase the capacity of the chlorine apparatus. Half-hourly tests of residual chlorine in the water applied to the filters were made by the potassium iodide starch method. The amount of chlorine was increased by steps until 18 lb. per million gallons or 2.16 parts per million was used. With this amount of chlorine no residual chlorine was noted in the filtered water when used in any quantity below the maximum, and there was no complaint of tastes or odors in the water delivered to the city. After the algae disappeared from the raw water, sharp reductions in the amount of chlorine used were necessary until the quantity of 4 lb. per million gallons was reached in December, 1921.

In August, 1921, trouble of an entirely different character occurred in the open 5,000,000-gal. capacity filtered water storage reservoir of the Davenport Water Co. A heavy growth of oscillaria developed. An attempt to control the growth by spraying the inside slope and the water around the edge of the reservoir, where the most active growth appeared to be, failed. By this time the odor and taste had become very objectionable and the neighbors were demanding that the reservoir be emptied and cleaned, on the theory that a bad smell meant unclean conditions. The reservoir was emptied and cleaned, in order to satisfy this public clamor. After the reservoir was emptied the slopes and bottom were washed with hose streams and cleaned with brooms. Calcium hypo-chlorite was sprinkled over the entire bottom and the reservoir again washed. Soon after the reservoir was filled with water, algae reappeared. Spraying along the edges was ineffective, and it was not until the whole body of water was treated with copper sulphate by dragging a bag of copper sulphate attached to a float back and forth across the reservoir, that the algae disappeared.

After the whole body was treated with the copper sulphate, the algae disappeared, and no more trouble was experienced during the fall.

Experiments with Rubber as Paving Material.—Some interesting experiments are being carried out in Ceylon, in the employment of rubber for public thoroughfares, and if these experiments prove a success similar trials may be proceeded with in Calcutta and other parts of India. The first of the new experiments is the use of a rubber mixture, and its efficacy is being tested on certain Colombo highways. The preparation is applied in the same manner as tar, and resembles it closely in appearance. After application, and before it hardens, the mixture is covered over with river sand to increase its durability. The second experiment is being made with rubber blocks. It is stated that rubber of a very inferior quality, mixed, if possible, with bark shavings, is the best for the manufacture of the blocks required, so that the cost will not be an insuperable objection.—Indian Engineering.

Locating Leaks with the Geophone.—A promising use for the geophone, an instrument invented by the French during the war to detect sapping and underground mining operations, is in the location of leaks in water mains. According to the U. S. Bureau of Mines, by means of the instrument, it is possible to hear water circulating in the pipes of ordinary city mains situated 10 to 15 ft. below the surface. Tests conducted at a busy corner in the downtown district of Pittsburgh located a leak in a water main which the water company had for two weeks vainly sought to detect.

Construction of Loch Raven Dam, Baltimore

Methods of Raising Structure 52 Ft. Described in Paper Presented at Last Annual Convention of the American Waterworks Association

By WM. A. MEGRAW.
Water Engineer, City of Baltimore, Md.

Baltimore is engaged in making what is known as the Gunpowder improvement to its water supply. The plans include a dam at Loch Raven on the Gunpowder river to impound 23 billion gallons of water, and a balancing reservoir to limit the pressure on a 7 mile tunnel conducting water to the city, together with the necessary relocation of roads and bridges, the purchase and removal of the villages of Warren and Phoenix, the relocation of 1.5 miles of Pennsylvania R. R. tracks near Phoenix, the purchase of about 4,000 acres of land from 54 different owners and clearing the ground to be flooded of buildings, trees and vegetable matter. The principal feature is the Loch Raven Dam, which is nearing completion. Plans were first prepared in 1913 and the work completed during the following year to elevation 188 ft. above mean tide, the base being made broad enough to support the additional section necessary for raising the dam later to elevation 270. The plans, under which the present contract is proceeding, provide to raise the dam from elevation 188 to elevation 240. The dam is a solid concrete structure, 640 ft. long over all. The spillway is 288 ft. long and raises about 103 ft. above bed rock.

Design Features of Dam.—In designing the cross section, upward pressure was assumed on all horizontal joints, equal to the full hydrostatic pressure at the upstream face, decreasing to zero at the downstream face. Porous drains in the horizontal joints are provided to relieve upward pressure. Two 48 in. pipes passing through the old foundations control the ordinary flow of the river and enabled all concrete to be deposited on dry surfaces. One inch bent steel rods, 5 ft. apart horizontally and vertically, imbedded 3 in. back of the down stream face, can be straightened to assist in binding the new concrete to the old, in case the dam is ever raised to a higher elevation.

The gate chamber is divided into two separate compartments and each is designed to supply the city separately. Fifteen sluice gates, 3½ ft. by 6 ft., arranged at different heights, control the entrance of water.

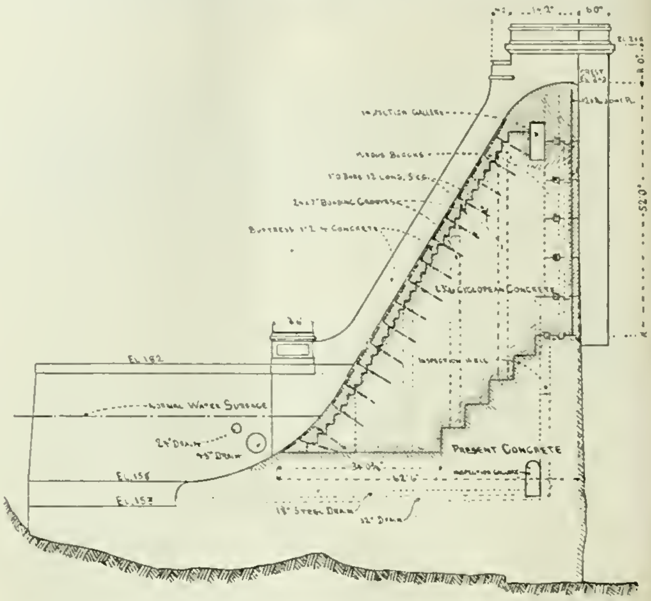
Location of Dam.—The dam is located between steep hillsides and the available working space is small. Stone was furnished from a city quarry located on the west side of the river 3,000 ft. down stream from the dam. An improved highway extends from a point on the hillside opposite and above the dam down to and past the quarry to Loch Raven Station on the Maryland and Pennsylvania R. R. about 2,200 ft. farther down. Loch Raven Station is about 11 miles from Baltimore. The railroad at Loch Raven Station is approximately at right angles to the river and follows along a steep hillside about 50 ft. above the highway, which turns and parralels the railroad in both directions. A siding about 1,600 ft. west of the railroad station provides a means of handling materials from the railroad by gravity to the highway below. An old city-owned siding 1.6 miles long is located on the east side of the river and extends from the dam southerly to a point where the railroad, 1.2 miles east of Loch Raven Station, meets it at grade. This arrangement of highways, railroads and sidings, offered several means of handling the work of construction.

The contract was awarded to the Whiting-Turner Construction Co. of Baltimore, on April 6th, 1921, and about July 1st, the first concrete was deposited. The bulk of the work was completed by Jan. 1st, 1922.

The Concreting Plant.—The specifications permitted the use of cyclopean concrete, but the contractor installed a chute system for distribution, which precluded the depositing of large stones, except in the east shore section, where a derrick, used for excavating the east abutment, swung a portion of the larger stones into the dam. The chute system was designed by the Lakewood Engineering Co.

On the west side of the river, the topographical conditions were ideal for a gravity plant. The contractor, availing himself of this advantage, located his crusher, storage bins and mixing and distributing plant up and down the west hillside just south of the site for the dam, although the city siding on the opposite side of the river connected the dam directly with the main line of a railroad.

Cement was the only material hauled by railroad. On the hillside below the siding at Loch Raven Station, a cement house was built with a capacity of 5,000 bbl. The cement was here received in bags and handled by a belt conveyor operated by a gasoline engine which also operated a bag shaker consisting of a wire cage rotating about 7 minutes for each charge. By means of a chute the bags of cement were passed to trucks. The trucks transported the cement to a 200 bbl. capacity shed located on the hillside above the plant, whence it was conveyed directly to the mixer platform by chutes.

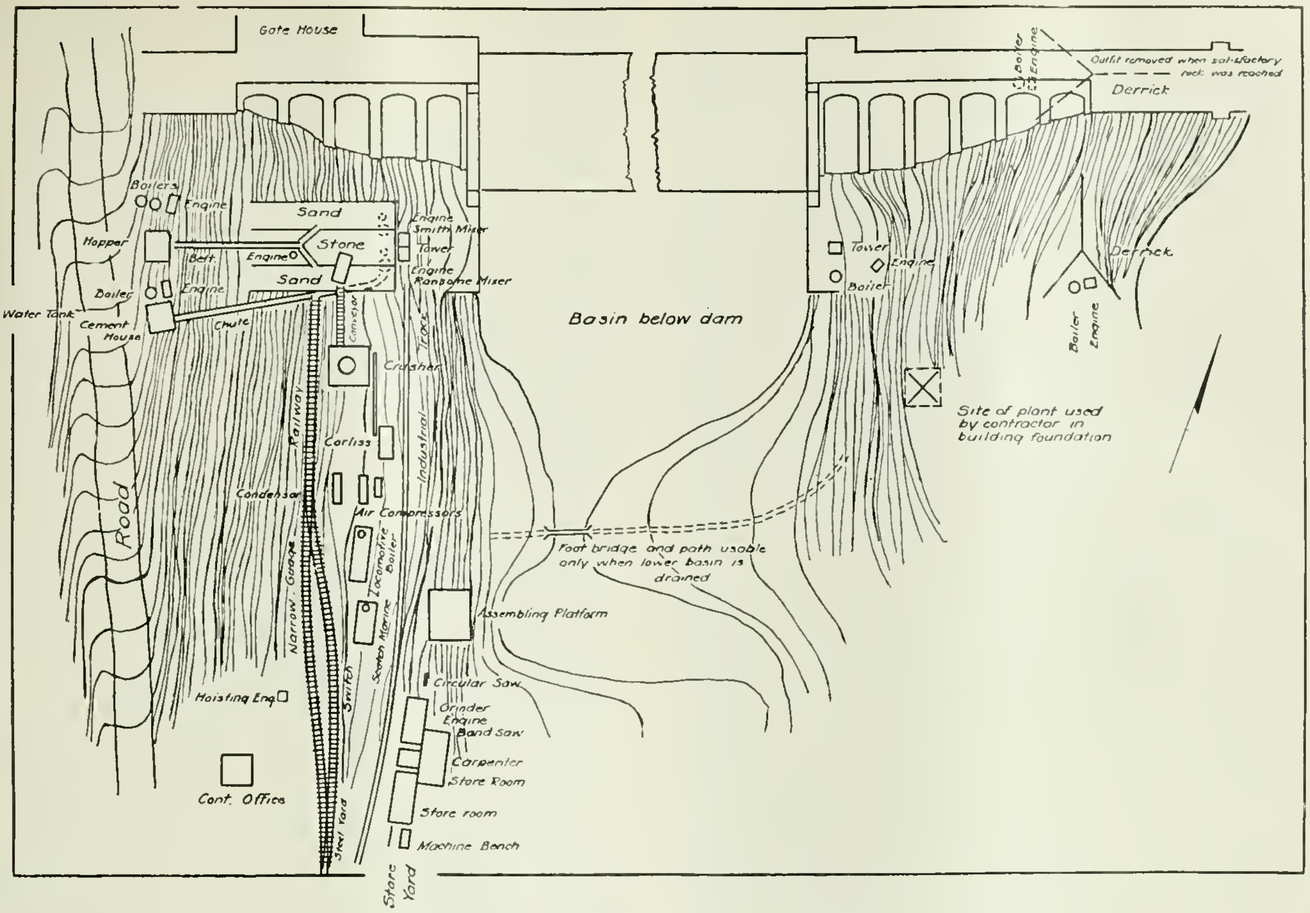


Cross-Section of Dam.

Sand Supply.—The neighborhood sand is generally not suitable for concrete, but the contractor was able to locate an excellent sand pit about 2 miles from the dam. The cost of sand at the pit was 24 ct. per cubic yard and the cost of trucking 44 ct. per cubic yard, making a total of 68 ct. for the sand delivered. The quotation for river and shipped from Baltimore was 70 ct. per ton plus $1.14 for freight, which is the equivalent of $1.45 per cubic yard. The contractor was thus saved 75 ct. per yard and the delays consequent to rail shipment. The sand was excavated by a ¾ yd. revolving steam shovel and transported by motor trucks to a point above the plant and dumped directly into a hopper at the elevation of the highway, from which a belt conveyor carried it to two large storage bins, one of which is located on each side of the stone bin. The total capacity of the two bins is 500 cu. yd.

The sand contained a maximum of 10. per cent of clay which was twice the amount authorized by the specifications. It was accepted only after thorough tests were made. One to three motar briquettes showed an average of 250 lb. per square inch, which is 50 lb. above the standard requirement. At different times, as the work progressed, 4 in. cubes were made from concrete as it passed from the chutes into the dam. The compressive strength of these cubes at the end of 28 days averaged 1,800 lb. for 1:3:6 concrete and 2,220 lb. for 1:2:4 concrete. The sand was well graded from small to large and contained a considerable percentage of gravel for which reduction was made in the stone. The clay seemed to lubricate the concrete, causing it to be more easily mixed, chuted and worked. The concrete produced a smaller amount of laitance than is usual and honeycombing is almost entirely absent from the dam.

Stone Obtained from City Quarry.—The stone was taken from the city quarry with no expense other than that of actual quarrying. For each blast, two large well drillers were used to put down about 10 holes 12 ft. apart and 85 ft. deep, located parallel to and 20 ft. back of the quarry face. Three large blasts, each requiring about 4,200 lb. of dynamite, made at different times as the work progressed, were required to throw down the necessary 45,000 yd. of rock.



Layout of Contractor's Plant for Raising Loch Raven Dam.

After each shot considerable secondary drilling was done by various kinds of drills, and tripod and jackhammer, besides a large amount of mud capping, in order to reduce the stone to stream shovel size. The air used by the drills was piped from the power plant located below the dam. A ¾ yd. shovel used at the beginning of the job soon proved insufficient and was replaced by a 90-ton Marion shovel for loading the stone into dump cars.

The cars were hauling ½ mile to the dam over a 36-in. gage track by an 18-ton dinkey, 4 cars constituting a train. As the track approached the dam, it was elevated on a trestle at 5.8 per cent grade and dumped directly into a 1,500-ton gyratory crusher. A hoisting engine was used to spot the cars up the incline to the front of the crusher, which enabled the locomotive to return for another train while the first trainload was dumped and crushed. From the crusher the broken stone was raised to an overhead bin by means of a belt conveyor. The stone bin has a capacity of 1,000 cu. yd. and is located between the two sand bins.

Water for the concrete is taken from the river above the dam and measured by two barrels pivoted on their centers and so placed that each will empty into a mixer by hand. Each barrel has a 2½-in. quick opening valve and a mark on the inside to indicate the quantity of water desired.

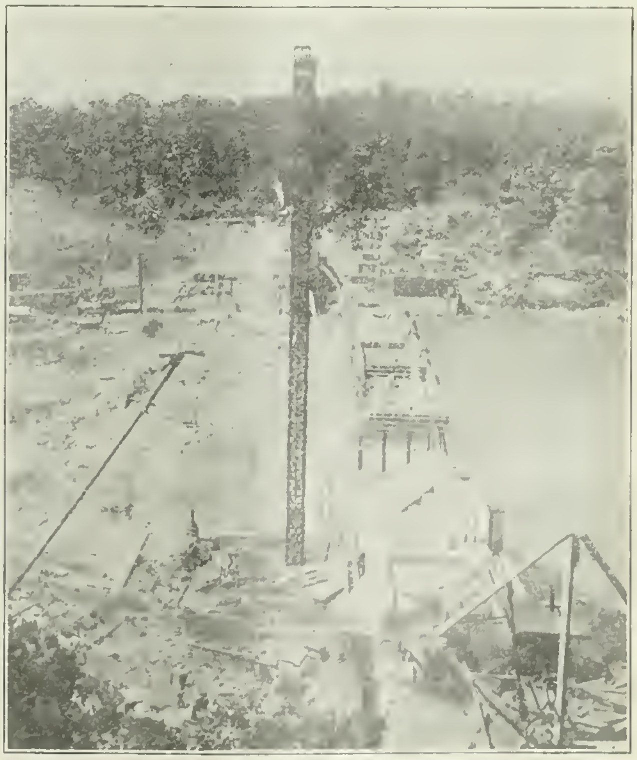
The sand and stone bins each discharge through a separate chute to a hopper located over a concrete mixer, the hopper being calibrated to measure the quantity of sand and stone required for one batch of concrete and designed to dump all material simultaneously into the mixers. Two 1-yd. mixers have been used; a Smith tilting mixer and a Ransome nontilting mixer.

The concrete is elevated from the mixers by buckets operating inside of a double wooden tower 2,048 ft. high and distributed by chutes to the desired points. The concrete buckets are raised by engines, one for each bucket, located at the elevation of the highway about 75 ft. above the bottom of the lower pit.

The dam is built in 60-ft. lengths, separated by transverse expansion joints extending continuously through the cross sections. Five-sixteenth inch by 12 inch vertical steel plates, placed 18 in. back of the upstream face, are intended to seal the expansion joints. The upstream face of the dam is composed of 1:2:4 concrete placed in 8 ft. lifts extending alternately 6 ft. and 7 ft. back from the face. The remainder of the section is composed of 1:3:6 concrete.

The Concreting Procedure.—The following concreting procedure generally was followed:

First, a lift of 1:2:4 concrete, 60 ft. long between expansion joints was deposited. After 12 hours the forms were removed and 1:3:6 concrete was then deposited in one oper-



View of Construction Operations at Dam.

ation from the back of the 1:2:4 concrete to the downstream face and for a full length between expansion joints. The 1:3:6 concrete was generally brought 1 ft. higher than the 1:2:4 concrete. The two grades of concrete thus break joints both horizontally and vertically and the only vertical joints, except the expansion joints, are those between the two grades of concrete.

Six inch by 12 inch horizontal bonding grooves, 2 ft. back of the front face and a 14-in. by 14-in. porous block drain 2 ft. further back from the face were placed in the 1:2:4 concrete at the completion of each lift. The bonding groove and groove for the tile drain were cut out by hand as soon as the concrete had sufficiently hardened. The ends of the tile drain are covered with burlap dipped in tar, and the space between the tile and groove filled with dry sand. At each expansion joint, the porous drain enters a 3 ft. x 3 ft. well, extending vertically upward and downward to galleries respectively above and below the highest and lowest horizontal joints, by means of which inspection can be made of the seepage through the dam. The lower gallery is drained into the tail water on the downstream side. Vertical bonding grooves 2 ft. wide by 7 ft. deep and 10 ft. apart, bond the masonry across the expansion joints.

Forms on Downstream Face.—The 1:2:4 concrete shown on the plans for the downstream face was omitted and 1:3:6, deposited as described above, was substituted. The placing of forms on the downstream face presented a problem. There was no way of supporting them from the interior without leaving considerable timber in the concrete and supporting them from the outside would have been expensive. The problem was solved by wiring the forms to dowels inserted in the existing concrete. A few props held the forms in place ready for pouring. As the concrete was deposited, the pressure soon became sufficient to keep the forms from collapsing, and the props were then removed. It was necessary to drill holes in the old foundation concrete, for the dowels, but above that elevation, at the end of each day's pour, as soon as the concrete had set sufficiently, pieces of scrap pipe were put in place to serve as dowels.

Placing the Gates.—In the gate chamber one 24-in. x 24-in. and eleven 6-ft. x 3.5-ft. gates were placed. The specifications provided that all gates be securely blocked and fastened in position before concreting. The gates will be operated by stems varying in length from 50 ft. to 75 ft. and were required to be set exactly plumb; but as each gate weighs 4,700 lb., it was practically impossible, with the means available, to sustain them in place while concreting around them. In construction, therefore, the bolts for the gate frames were set as the concrete was deposited and the gates and gate frames were set after concreting of the gate chamber was completed.

The rock stratification on the east hillside is so much inclined from the horizontal that it was impossible to expose a large face without causing a rock slide. It was possible, however, by stepping the foundation to keep a rugged wall of rock against which to place concrete. About 2,000 yd. of solid rock was estimated, but owing to the sliding tendency, over 5,000 yd. was excavated. Excavation for the east abutment was started before completion of the construction plant, yet, due to the difficulties encountered, this portion of the dam was the last completed.

In order to convey concrete from the mixers on the west side of the river to the easterly part of the east abutment, the concrete was rehandled at the east tower. An elevator bucket within the tower was filled from the line chute, then elevated, and the contents emptied into a second chute higher on the tower. The east tower is 168 ft. high and the west tower 204 ft. high. The towers are 340 ft. apart and connected by a 1¾-in. cable which carries the concreting chute.

The capacity of the plant is about 600 cu. yd. of concrete per 10-hour day, although at times 755 cu. yd. have been placed in the same time. The average per working day was 300 cu. yd. A considerable portion of the contractor's plant had been used before, but the loss due to breakdowns was not excessive. The records of the resident engineer show a loss of 483 working hours. Of this time 48 per cent was due to breakdowns and other troubles with the mixers, 22 per cent due to changing and clogging of chutes, 14 per cent due to accidents in the towers and 15 per cent due to lack of forming space and other causes. On the whole the work progressed with rapidity, which was due in part to the hearty co-operation between the contractor and the engineers.

The Construction Plant.—The following is a list of the contractor's equipment:

1 Marion 31 revolving steam shovel.
1 Erie type B revolving steam shovel.
1 Marion 61, railroad type, steam shovel gasoline pumping outfit.
1 18-ton Vulcan narrow gauge dinkey.
1 14-ton American narrow gauge dinkey.
10 Koppel 4-yard dump cars.
10 Western wheel scraper 4-yard dump cars.
1 325 cu. ft. Ingersoll-Rand steam driven air compressors.
1 160 cu ft. Chicago pneumatic tool air compressor.
1 Bulldog 20-in. gyratory crusher, rated capacity 1,500 tons in 10 hr.
1 175 h.p. horizontal Corliss valve steam engine, driving crusher.
1 24-in. rock bucket elevator.
2 20-in. belt conveyors—1 driven by 12 h.p. vertical steam engine, and 1 by 12 h.p. Otto gasoline engine.
1 Link belt sand washer.
1 Steam driven Duplex pump, 6-in. suction, 5-in. discharge, for general water supply.
2 Duplex boiler feed pumps.
1 15,000-gal. wooden tank for water supply.
1 150 HP. locomotive type boiler.
1 150 HP. Scotch marine boiler.
1 60 HP. vertical boiler.
1 30 HP. vertical boiler.
1 Ingersoll-Rand drill sharpener, air operated.
1 Circular saw.
1 Band saw.
1 Grinder.
1 Power operated pipe-threading machine.
1 Contractor's equipment 7½x10 double drum hoisting engine with boiler.
1 3-drum 8x12 Munday hoist with boiler.
1 8¼x10 double drum Lidgerwood hoist with boiler.
1 8x10 Lidgerwood hoist with boiler.
1 5x8 double drum hoist with boiler.
1 7x10 American double drum hoist with boiler and boom swinger.
1 8½x10 double drum Lambert skeleton hoist.
1 6½x12 double drum Mundy hoist.
1 Stiff-leg derrick, 15-ton capacity, with 65 ft. boom.
1 Stiff-leg derrick, 15-ton capacity, with 60 ft. boom.
1 Stiff-leg derrick, 5-ton capacity, with 50 ft. boom.
1,200 ft. of Lakewood chutes.
2 No. 3½ Keystone well drills.

About 45,000 yd. of concrete are required under the present contract, and the cost of all items will amount to about $525,000. The principal unit prices are as follows:

Loose rock excavation	$ 4.69 per cu. yd.
Solid rock excavation	6.67 per cu. yd.
Concrete for balustrades	20.60 per cu. yd.
1:2:4 mass concrete	11.85 per cu. yd.
1:3:6 mass concrete	10.34 per cu. yd.
Steel reinforcement	.04¾ per lb.

Fifty thousand eight hundred cubic yards of 1:2:5:5 and 1:2:4 concrete were placed under a previous contract, the cost of all work under which amounted to $527,000. The total cost of the dam from bottom to top is, therefore, $1,052,000.

The writer is indebted to Mr. C. K. Allen, resident engineer, for a portion of the information contained in this article.

Underground Topography and the Construction of Sewers

From Municipal Engineering and The Sanitary Engineer.

That a knowledge of underground topography is of great importance to all concerned in the construction of sewers, is made evident from the following experiences of a leading engineer:—A shaft was sunk in dry ground and work had proceeded a considerable distance when, on entering the work one morning the workmen found to their dismay the tunnel half full of water. The water had seeped in over night through a sand seam. This seam followed the work for the remainder of the job. It was narrow at first, gradually widening out until it was several feet in thickness and later turning to a very wet mixture of clay and sand. (Compressed air had to be resorted to.) On the other side of the shaft, the ground, although clay loam at first, changed rapidly from clay to sand, fine gravel, coarse gravel, and then hard clay. This sand and gravel carried much water. A short distance away the ground was a hard dry clay which had to be removed by blasting. This clay contained at the elevation of the tunnel (30 ft. from the surface) small branches of trees. There had evidently been in the past a creek through this part of the land, which had long since been filled in, either by natural or artificial means. The old banks were, no doubt, sedimentary, as evidenced by the branches. In many other cases which could be mentioned, similar rapid changes could be cited both in open cut near the surface and in tunnel far beneath it. Generally, in cases where bad conditions are met with, compressed air is used, and in one such case recently a curious thing happened. A bidder had put down a boring to test the condition of the ground, and later, when the tunnel in which compressed air was used, was passing the boring, the air, following a seam the boring had tapped, forced water up through it in such quantity as to give the appearance of a large fountain.

A Survey of 15 Sewage Treatment Plants

Resulting Conclusions Given in Paper Before Western Society of Engineers

By H. H. WAGENHALS,
Assistant Sanitary Engineer, U. S. Public Health Service.

During the summer of 1920 the United States Public Health Service undertook a survey of 15 sewage treatment plants, located in 12 cities in different parts of the country, and considered to exemplify different processes and different conditions. The objects of this survey were: (1) To obtain a bird's-eye view of the field of sewage treatment; (2) to secure basic data by which the efficiency of service could be judged; (3) to suggest some standard tests which might, without undue labor, be adopted at all plants so that results at different plants would be comparable.

The following plants were surveyed: Two Imhoff tanks and trickling filter plants without secondary sedimentation at Atlanta, Ga., and one at Columbus, O.; a combination of plain sedimentation and Imhoff tanks followed by contact beds and final intermittent fine cinder or sand filters at Alliance, O.; Imhoff tanks with contact beds at Canton, O. (the last two having glass-covered sludge drying beds); hydrolytic tanks, fine screens, trickling filters, secondary sedimentation and sludge digestion tanks at Baltimore, Md.; Imhoff tanks, trickling filters and secondary sedimentation at Rochester, N. Y., Fitchburg, Mass., and Lexington, Ky.; septic tank, trickling filters and secondary sedimentation at Reading, Pa.; fine screens, Riensch-Wurl, followed by Imhoff tanks and disposal by dilution without oxidation at Rochester, N. Y.; and activated sludge at two plants at Houston, Tex., and at San Marcos, and Sherman, Tex.

Raw Sewage.—Except at plants treating sewage from separate sewer systems, the total flow was not ascertainable, because of the wastage by overflows or by-passes, which are used when the flow exceeds the maximum capacity of the treatment plant. The volume passing through the treatment plant was known fairly accurately at all but the two smallest plants, where the flow averaged, as actually measured on the survey, less than a half million gallons daily.

The per capita volume treated averaged very close to the commonly used figure of 100 gal. per day, it being about 94. There were 9 with smaller and 6 with larger flows. Six were within 10 per cent of the average, five within 25 per cent, and four from 36 to 58 per cent.

The number of people served per sewer connection averaged 5.4, with variations from 3.8 to 7.1. The number of connections was not known at four places.

The character of the sewage received at the different plants varied, as would be expected, within wide limits. Suspended matter ranged from 101 to 297 parts per million, averaging 174. Except at plants where an unusual amount of industrial wastes is discharged into the sewers, as at Gloversville, N. Y., it is not probable that many municipal sewages are more concentrated than some of those studied, and sewages with less than 101 parts per million of suspended matter are seldom encountered. It is believed, therefore, that the survey included a good cross section of American sewages.

Solids settleable in two hours in Imhoff glasses ranged from 1.9 to 4.9 c. c. The values obtained from this determination do not correspond very closely with the suspended matter obtained by the Gooch crucible. Readings of 4.8 and 4.9 c. c. were obtained with sewage containing 261 and 264 parts per million of suspended matter, whereas only 2.7 c. c. were settled from the sewage containing 297 parts per million, and 2.0 c. c. from the least concentrated sewage containing 101 parts per million, and also from two other sewages containing as high as 226 parts per million.

The oxygen-consumed values, by the 30 minutes in boiling water method, ranged from 24 to 69 parts per million, averaging 44.

The 5-day biochemical oxygen demand averaged 114 parts per million, the maximum value being 190 and the minimum 67.

Imhoff Tanks.—While Imhoff tanks were in use at 10 out of the 15 plants, at two plants the effluent from the Imhoff tanks was mixed with that from other types of tanks with which they operated in parallel, and the samples analyzed were the mixed effluents. On the whole, the Imhoff tanks performed their function of removing suspended matter very satisfactorily, the average removal amounting to 59 per cent. At only two plants was it below 60. These being 37 and 40, pulled down the average. Accompanying this the biochemical oxygen demand was reduced 42.5 per cent, and the permanganate oxygen consumed 36 per cent. The last two figures are rather interesting in that the reduction of the 5-day oxygen demand was greater than that of the oxygen consumed. Studies of industrial wastes by the U. S. Public Health Service at Cincinnati, O., have indicated that the removal of solids affected the oxygen consumed to a much greater degree than the oxygen demand.

As affecting subsequent treatment, the actual amount of suspended matter in the tank effluent is of more importance than the per cent removed by the tanks. The Imhoff tank effluents at half the plants contained between 60 and 70 parts per million; three contained more, the highest being 119, and one contained only 40. The effluent containing 119 parts per million received no subsequent treatment. Detention periods for normal flows averaged about four hours, computed on a total displacement basis, and, with this detention period, the velocity averaged about 0.6 ft. per minute.

Foaming appeared to be more of an occasional nuisance than a serious difficulty of operation. With but one or two exceptions, most of the tanks foamed at one time or another, but relief could be obtained by the withdrawal of sludge. This method was accepted by all the plant operators as the only one capable of giving permanent relief.

The capacity of the digestion chambers, below the overlap of the slot, averaged for all 12 installations 1.3 cu. ft. per capita served; but omitting two parts at which this factor was purposely made unusually large, both being 2¼ to 2½, the average for the remaining 10 plants was 1.1.

Considering the variations in the character of the sewages entering the tanks at different places, and the differences in the many design factors, it is not possible to compare the efficiencies of tanks at different plants on the basis of any selected design factor. In a general way, it seems that refinements in minor features do not materially affect operation.

Trickling Filters.—Trickling filters were studied at eight plants. At six they were preceded by Imhoff tanks; at one by hydrolytic tanks, with a small admixture from Imhoff tanks; and at one by a septic tank. The depth of the filters ranged from 5 to 10 ft.; but at six of the eight plants the variation was from 5 to 6 ft.

The rates of filtration fell for an equal number of plants above and below 2 m. g. d.; but at two of the four plants operating in excess of this rate, there was sufficient filter area available to effect rates below 2 m g. d., if it was all used regularly.

The physical appearance of the effluents was good at all except one plant, and this plant was the only one at which there was any appreciable pooling, though the surface layers of several others exhibited considerable clogging. When it is remembered that some of these filters have been in continuous operation for 10 to 12 years with very little expense other than occasionally going over the surface with a pick or harrow or flushing with a hose, there appears to be little reason to anticipate any material decrease in efficiency.

The analytical results obtained from all the effluents, with the exception of those from the pooling filter, were good. One of the most interesting results obtained from the studies of these plants was the uniformity of the final effluents. The raw sewages pretty well covered the range of concentration of American sewages. Preliminary settling, however, in tanks of totally different design and operation produced effluents of remarkably similar character, and the trickling filter effluents were all of such like composition that they could well be expected to have come from the same filter in a period covered by the survey as a whole.

Suspended matter determinations may be misleading or meaningless for trickling filter effluents, as this constituent varies so greatly with the cycle of operation of the filter, from the storing period to the unloading period. The character of the solids in the filter effluent is, moreover, totally different from that in the influent.

The filter is an oxidizing device and its efficiency must, therefore, be judged by determinations involving the presence of oxygen Three such determinations were made: The oxygen consumed, the oxygen demand, and nitrogen as nitrates. This last determination is of relatively little value unless the amount of nitrogen in other forms present in the influent is known. Low nitrates in themselves mean very little.

Omitting the one clogged filter already mentioned, the oxygen-consumed values for the plants studied fell within the relatively narrow limits of 7 and 19, and the 5-day oxygen demand values between 4 and 20. The one pooled filter had an oxygen-consumed value more than twice the average of the other filters, and a 5-day oxygen demand about two and one-half times as great as the maximum value for the other filters.

Another interesting fact brought out by the analytical work was the reduction of the methyl orange alkalinity by the filters. At all except one plant this reduction amounted to over 30 per cent, and at one plant it was 92 per cent—from 99 to 8 parts per million. We could not undertake to obtain sufficient analytical data to definitely assign any reason for this reduction, but it may possibly be due to the use of CO_2 by bacterial activities in the filters which, when taken from the soluble bicarbonates in the influent, reduces these to insoluble carbonates, which are retained in the filter. This same reduction in alkalinity was found in all properly operating oxidizing devices, such as contact beds and aeration tanks of the activated sludge process.

Contact Beds.—Contact beds were studied at Alliance and Canton, O. While they did not produce results equal to the average of the trickling filters, the effluents were entirely satisfactory for ultimate disposal with the dilution factors available. The oxygen-consumed values were 11 and 18, and the 5-day demand values 20 and 37, respectively, for Alliance and Canton. At neither place are these filters operated during the winter months.

Fine Screens. Fine screens were found at Rochester, N. Y., and Baltimore, Md.. At Rochester, Riensch-Wurl screens precede Imhoff tanks and serve to keep large floating solids from the surface of the tanks and of Lake Ontario into which the Imhoff tank effluent is discharged. At Baltimore, rotating drum screens, similar to the Weand segregator, follow the tanks and serve to remove solids likely to clog the trickling filter nozzles. Their efficiency is best represented by a reduction of about 87 per cent in nozzles cleaned after the installation of the screens.

The analytical methods used in the survey failed to show any accomplishment by the screens at Rochester during the period of the survey. Suspended and settleable solids and oxygen consumed were slightly higher in the effluent than the influent, and the oxygen demand was slightly lower; but in none of the determinations was the difference of any significance. Computing from the screenings collected back to equivalent solids, the removal amounted to less than 1 or 2 per cent.

Activated Sludge.—Four activated sludge plants were studied at three Texas cities. At Houston are the two largest plants in actual permanent operation in this country. At San Marcos is the reputed first municipal plant of this type; it is of very small capacity, as is also the plant at Sherman. The smallness of these plants makes them worthy of study, in view of the stated opinions of some engineers that this process is adapted only to large installations, where highly paid operators are in charge and where there is sufficient sludge to warrant its profitable recovery.

The San Marcos plant, treating less than 200,000 gal. per day, was the smallest plant studied. In actual man-hours it received much less attention than any of the other plants, with the possible exception of the Sherman plant. A good general utility man visited the plant every day to oil the machinery and make a brief general inspection. The influent was a weak domestic sewage, and it was passed through a septic tank before entering the aeration tank. The effluent ranked well among the best of those studied, with a suspended matter content of about 3 parts per million, an oxygen-consumed content of about 8, and a 5-day oxygen demand of 16, with ample contained oxygen in the form of dissolved oxygen and nitrates to more than satisfy this demand.

The cost of operation per million gallons naturally was high, amounting to about $20, including interest on the money invested. This is equivalent to an annual cost of $1,400, or about 56 ct. per capita served, which, considering the contributing population of 2,500, does not appear excessive.

This plant may be taken to illustrate the adaptability of the activated sludge process to small installations, and it brings up the question of the value of presettling the sewage before aeration in such installations, where the recovery of the commercial value of the sludge is not feasible.

The value of the activated sludge process for small installations may also be considered from another angle. It obviously is not entirely automatic. I feel that too much emphasis has been placed on the so-called automatic operation of other types of sewage treatment devices. Many, one might almost say most, small sewage plants have been installed with the idea firmly rooted in the minds of the city officials that the plants will run themselves. Certainly it must be admitted that the officials' actions bespeak such convictions. It seems that there might be a distinct inherent advantage in a process which must require some attention to operation. Motors and blowers or air compressors cannot run day after day without oil at least. Moving machinery must be cared for. To insure a daily visit to the plant is of real value.

It appears possible that the activated sludge process may find its greatest field of usefulness in small installations rather than, as is at present held, in the large ones. In small installations, and especially with presedimentation, the sludge problem is greatly reduced, whereas with large installations, present opinions predicate its economic feasibility upon the commercial value of the sludge produced and the cost of its reduction to a commercial form.

The plant at Sherman, Tex., did not present as optimistic a picture as the one at San Marcos. The effluent was comparable with that from the already mentioned pooling trickling filter. The sewage was extremely concentrated, receiving night soil from a population about equivalent to that connected to the sewers, and this night soil was dumped into the sewers so close to the treatment plant that it reached the plant in an almost unbroken condition. The installation of a preliminary settling tank might greatly facilitate the operation of the aeration tank; but even then better operation would be essential to produce a uniformly first-class effluent.

Both of the two large plants at Houston produce excellent effluents. There is no longer any doubt of the capability of the process to effect adequate treatment. The problem at Houston, as at all large plants of this type, is the ultimate disposal of the sludge produced. There are great possibilities and promise of ultimate solution of this problem, but so far no sludge-handling plant has operated sufficiently to demonstrate either success or failure. No new data on this subject could be secured during the survey. The attitude of most engineers still remains a mixture of anticipation, hope, and doubt.

Utilization of Sludge.—Utilization of sewage sludge usually carries the idea of some ambitious scheme for the preparation of a market fertilizer from the sludge which will result in large financial returns. Sludge for the most part takes the extremes (a) of being no earthly good, a valueless waste, a liability to dispose of; or (b) of being possessed of so much value that it must pay not only for its own disposal but also for a portion of the cost of the treatment of the sewage. The saving of the expense of hauling the sludge from the plant to a dump and any small revenue for its sale have in most places not been considered worth the trouble of creating a local demand.

At three of the plants visited—Alliance and Canton, O., and Rochester, N. Y.—the sludge is all used by local farmers. At the time of the survey Rochester was the only place where any charge was made for the sludge, but at the other two places the growing demand will probably eventually give to the sludge a commercial value.

The psychology of disposal to local farmers has recently been well expressed by Mr. N. A. Brown, of Rochester, when he said that as long as sewage-treatment officials themselves tell the farmers that the sludge has little if any fertilizing value, the farmers will not be inclined to haul it away, but that if the farmers see that the officials think it worth selling, they will not only haul it away but will pay a price for it.

The average farmer is practical when it comes to hauling fertilizer. If he does not get any benefit, he stops using it. And yet at the three plants visited and also at Lexington, Ky., farmers are calling for the sludge year after year, and taking ever-increasing amounts.

I do not want to give the impression that I consider sewage sludges market competitors of commercial fertilizers. But I do believe that at most sewage treatment plants a local demand for sludge can be created on an actual value basis which will not only be the means of the ultimate disposal of the sludge but will produce a revenue which will, at least partially, pay for the cost of handling the sludge after its removal from the tanks.

Causes of Failure of Sewage Treatment Plants.—There are three possible causes for failures of sewage treatment plants: (1) The processes may not in themselves be capable of producing a good effluent; (2) the design of the individual plant may be at fault—capacities of the devices inadequate to handle the load placed upon them; and (3) poor operation or, as is often the case, no operation at all.

The first of these presents the most serious aspect. Opinions have been expressed, even among those familiar with sewage treatment, that the whole system and theory of sewage treatment practices has fallen down. This feeling has gained some ground among the uninformed who have come into contact with conspicuous failures of plants supposedly of the best design and supposedly entirely automatic.

The second cause of failure is restricted to individual plants and can be largely eliminated when the public and especially city officials thoroughly understand that the designing of treatment plants is a specialized branch of professional engineering and that such plants are not a part of the city's plumbing system.

Finally, failures due to poor or to no supervision of operation will gradualy be reduced by education and expensive experience.

This 1920 survey by the Public Health Service was primarily concerned with the first and most serious alleged cause of failure. For this reason the plants selected for study were those which were considered to have been properly designed by engineers versed in the principles involved and which were receiving good or at last reasonable attention and operation.

It was originally planned to continue the studies in subsequent years, specializing in plants where design was at fault and where supervision of operation was obviously below a required minimum. It was also intended to study the adaptability and efficiency of the different principles of treatment at smaller installations than those studied in 1920. These studies have, however, been at least temporarily abandoned.

Review of Results of the Survey.—In reviewing the results of the survey as a whole, there does not appear to be much ground for pessimistic criticisms of general theories of sewage treatment on the basis of their failure to effect adequate purification. All municipal sewage must ultimately be disposed of by dilution in some body of water, and the purpose of treatment is to prepare the sewage so that it will not produce objectionable conditions in the receiving body of water or, in some cases, place an undue load on a water purification plant using the receiving body of water as a source of supply. To these may be added the protection of bathing beaches, oyster beds, etc.

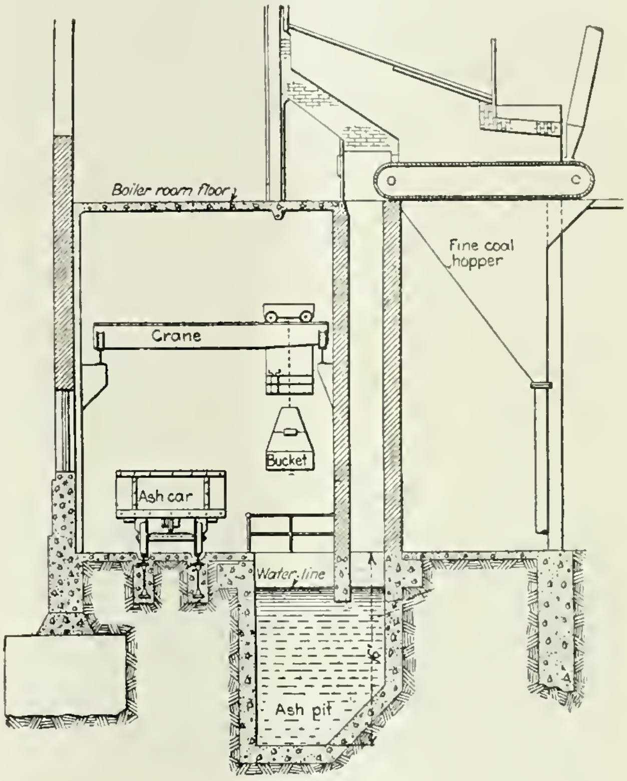
The primary function of preparing sewage for disposal by dilution without creating objectionable conditions was the main objective of the plants studied. No bacteriological analyses were attempted.

With but one or two exceptions, physical observations and analytical results agree that the plants visited were accomplishing the main object of their existence. All plants were seen during the warm months, the critical period of the year. At only 2 out of the 14 operating oxidizing devices was the color reduced in the methylene blue putrescibility tests of the effluents, which were incubated at room temperature. At one of these two the samples stood up for three to eight days. Only four of them had biochemical 5-day oxygen demands in excess of 20, and all had contained oxygen to partially satisfy this demand. With any reasonable dilution factor no objectionable conditions should be created with the effluents from the oxidizing devices studied. In addition to oxidation, the treatment processes removed practically all of the settleable solids.

A Water-Filled Ash Pit for Boiler Plant

An ash-handling installation in which the ash is discharged through a shaft to a water-sealed pit, has been in service at the North East Station of the Kansas City, Mo., Power & Light Co., for the past 2½ years. The arrangement is described in Power by Edward L. McDonald, Combustion Engineer of the company.

In operation the refuse, dropping from the rear end of the chain-grate stoker, falls through a 3x10-ft. shaft, into a water-filled pit 30 ft. below. The slope of the pit causes most of the ash to roll out into the open section. The rear wall, extending 4 ft. below the normal water level, prevents air from entering the shaft.



Water Filled Ash Pit.

In this installation each pit is 24 ft. long, 11.5 ft. wide at the center and 16 ft. deep, with a capacity of 2.3 tons per linear foot, sufficient for approximately 56 hours' operation of two 10x17½-ft. stokers set under a 13,500-sq. ft. boiler operating at 200 per cent of rating. This is the operating capacity of the pit, as the submerged wall will not permit utilizing the full volume.

An electric bridge crane, equipped with a 1½-cu. yd. clamshell bucket, is used for removing the ash from the pits. This bucket has a number of ¾-in. holes drilled through the plates to allow the water to drain back into the pit while the bucket is being raised to the height of the ash car. Some of the water, of course, is deposited with the ash in the cars, but practically all of this finds its way back into the pit through properly installed door drains made large enough so that plugging with fine ash is a remote possibility.

Removing Pipe Joints with Oxy-Acetylene Torch.—The problem of removing a 36-in. cast iron water main was simplified, according to The Welding Engineer, by using the oxy-acetylene torch to melt out the lead caulking between sections. It was found advantageous to adjust the acetylene supply to obtain a longer flame than that used for welding, in order to insure its penetration and the melting out of all the lead to the bottom of the joint. The operator begins at the top of the pipe joint and works down each side until the lead has been removed from about two-thirds of the circumference; after this has been done, the length of pipe is slightly lifted at the opposite end, and if necessary wedges can be placed on the inside of the end to be removed, so that when the pipe section is lowered it readily draws the joint away. The molten metal flows in bulk and is easy to collect, so there is no waste.

Economics of Water-Power Development

Production, Maintenance, Selling Costs and Fixed Charges, Discussed in Paper Presented May 9, at Spring Meeting of American Society of Mechanical Engineers

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Economics as applied to this particular subject relates to the planning and administration of hydroelectric plants in a manner such as to avoid wastefulness and extravagance.

The question of water-power development as a paying proposition, however, is another matter, and since each of these concepts covers a very wide field, it seems preferable at this time to touch, in a very general way only, on the essential factors pertaining to both problems in such a manner as to elicit profitable discussion thereon.

Only in very rare instances is it practicable to depend on water alone for the production of power for commercial purposes, and auxiliary power sources are therefore presumed to be a necessity and their construction and operation is herein considered as concomitant to water-power development.

The power business is akin to that of manufacture, as this term is usually conceived, and the conduct of this business is in many respects successful or unsuccessful in that measure in which the precept for efficient and profitable manufacture are observed.

In other respects special problems are presented because the product after manufacture must be sold and delivered to the consumer, for instantaneous use in a circumscribed market; and while the selling cost is dependent entirely on the immediate operation of the law of supply and demand, the selling price is generally fixed by regulation.

Just as this is true of any manufacturing enterprise, the success of a power development depends not alone on the perfection of the Physical Structure, i. e., the mechanical equipment, and the Production Structure represented by the operating personnel, but in even greater measure on the efficient functioning of the Commerical Structure and the adequacy and flexibility of the Financial Structure. Many monumental developments are, by the well informed, known to be failures.

It should be readily appreciated, therefore, that in any abstract discussion such as this it is impracticable to attempt anything beyond merely setting forth various items that particularly require consideration in an analysis of the commericial features of a power development, and pointing out in general terms their effect on net earnings, or the margin between selling cost and selling price.

Factors of Selling Costs.—Selling cost is made up of raw-material cost, fabrication cost and delivery cost. In each of these costs we have both variable elements subject to fluctuation with quantity production and susceptible to modification, and fixed elements which are not affected by applied economics, once the physical structure has been completed.

To each of these classified accounts there must of course be disbursed, either directly or in proper proportion, managerial supervision, clearical expense, cost of tests and experimental research, and a multiplicity of similar charges which occur in all manufacturing business and involve no peculiar features The raw-material cost may be determined by any or all of the following items: rental of water; land and water rights for reservoir; conditioning of reservoir; hydraulic control works; fuel delivered to plant; fuel-handling and storage facilities.

In establishing the feasibility of a development in view of these items, it should be noted that the unit cost of fuel is indeterminate unless quality is fixed by specification. The cost of fuel itself fluctuates with the market, generally in such a manner as to affect all competitors alike. Loss or deterioration in storage is a variable applying equally to fuel or water in a reservoir, and for water as well as fuel the unit cost is indeterminate unless quality and quantity are fixed by specification.

The cost of overflowed lands determines a fixed charge but the useful volume of water available and the effective head at which it may be used are variables, the proper determination of which constitutes the most difficult task involved in power-plant engineering and without the determination of which no unit is established for distribution of the cost.

Curiously enough, the requirements, of purchases of the product of this factory have a decided influence on the unit cost of the raw material, because while water may momentarily be available, its non-use at that particular moment may result in its utter loss. Prevention of such loss, to the greatest possible extent, is of course an extremely important consideration in the planning of details of the development.

The cost of structures, such as dams, gates, pipe lines, coal crushers, oil tanks, etc., determine fixed charges for water or fuel. Operation and maintenance of these structures are variable, and in planning them the engineer may choose whether fixed charges or the variables shall be increased or decreased. For instance, on the one hand a reservoir may be carefully cleared and the expense of so doing becomes a capital cost, or on the other hand only little clearing may be done and floating debris must then be removed from the racks from time to time. The expense then becomes an operating cost.

Fabrication Cost.—Of the three cost elements, fabrication is least affected by fortuitious circumstances. In a broad sense this cost is made up of fixed charges growing out of the capital cost of erected power-generating equipment, suitability provided with necessary or desirable adjuncts, housed or located outdoors as the case might be, and of operating charges which include wages, supplies, repair parts, etc. Capital cost of the plant may, however, and quite properly so, lie between wide limits for the same output of product, depending on two totally distinct provisions; uniformity of stream flow and character of service requirements, both as to continuity and uniformity.

It must be borne in mind that the manufactured product is kilowatt-hours, that the time element is just as important as the capacity element and that, in general, a sale is consummated only when capacity is available at the instant of use and for the period of use. Thus the hours of use for any given market must be most carefully predetermined for the proper selection of prime movers, and beyond this capacity must also be provided equivalent to the maximum instantaneous demand for current, else the product will not be salable.

It is readily apparent, therefore, that, in general, only one-half as much generating equipment is necessary for a 24-hour load as for a 12-hour load and that for a 24-hour load only one-half as much equipment is required to produce a perfectly uniform output as for a demand which fluctuates from zero to double the average load.

Capacity for the water-power plant having been fixed by the character of the load, there follows the determination of proper capacity for the auxiliary plant.

While this choice may possibly be dependent on a volume of output imperative continuous, it is much more likely that it will hinge on meteorological critera. One need only to mention that, in the first place, the run-off from any drainage area or the discharge of a stream fluctuates between very small quantities at times of drought and quantities sometimes many thousand times greater when in flood with, in general, little regularity about the occurrence of either stage, and that, in the second place, the average usable discharge for some years is considerably lower than for others.

Determination of Steam Flow.—Natural stream flow is determined either by measured discharge or by computed run-off based on recorded rainfall. From these data there is estimated the average annual stream flow and these determinations will approach correct values according to the length of the period of observations considered. These findings should be modified by an accuracy factor.

Depending on the topography of the development site, either at the power plant or on the drainage area above it, storage capacity may be created of such extent as to afford either daily or seasonal regulation. By daily or weekly regulation is meant the conservation of natural stream flow during either 24 hours or 7 days for use during those hours only when load can be sold. By seasonal regulation is meant the controlled, artificial increase of natural stream flow out of water stored during periods of run-off in excess of the usable quantity.

Regulated stream flow having been estimated for each year and for the average of all years of record, it will be found that, when daily discharges are plotted as shown on Fig. 1, one can very readily forecast what power output is continuous and what additional output may be sold for any predetermined portion of the year, as is fixed by low-water stages.

For high-water stages, while there will be an excess of water available, it frequently happens that loss of head results from this cause and in that event restriction of output must be determined similarly as for low-water stages.

Only in exceptional cases is it commercially practicable to develop a water-power plant for an output based on absolute minimum stream flow, and it is therefore customary to base earnings on that output which may be produced in the average year.

Equipment of Auxiliary Plant.—The equipment of the auxiliary plant is then primarily fixed by that capacity which may be necessary to supplement the water output of the lowest year to bring it up to that of the average year. Beyond this, except for possible emergency capacity, it becomes a question of dollars and cents, based on salability of secondary power and rates which may be secured for this service, as to the extent to which one can afford to install auxiliary equipment for the conversion of short-term water output into continuous combined water and auxiliary output.

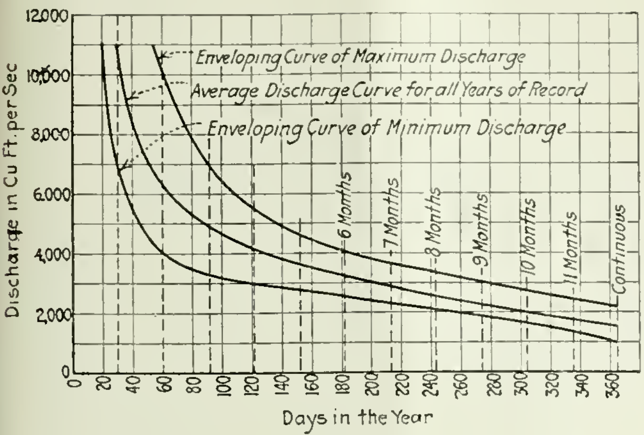

Fig. 1.—Stream Flow During Various Portions of the Year.

Dependent on local conditions, the capacity which must be installed for emergency service might finally be the determining factor in equipment selection. It may happen that in flood a water-power plant may be completely incapacitated through loss of head so great as to make impossible the maintenance of synchronous speed. Ice blocks also might completely prevent operation of a plant. For such cases, under certain load conditions it might become imperative to provide 100 per cent stand-by capacity.

Legitimate capital cost and resulting fixed charges must therefore be most carefully determined for each individual project and comparative figures are not necessarily indicative of their propriety.

Another so-called fixed charge is quite beyond control and that is taxes. Cost of supplies and repair parts are regulated by the law of supply and demand and cost of labor may or may not be determined similarly according to the extent to which organized labor can enforce its dicta as to rules and rates.

One phase of control as to fabrication cost is of particular importance in this business and that is the continuous, most efficient conversion of raw material into the finished product. This is not a question of workmanship but rather one of intelligent direction. Loss in kilowatt-hours produced out of available water and per unit of fuel may, under improper allocation of part loads to various equipment items, be considerable and difficult of detection.

Delivery Cost.—Delivery of power may be effected either direct to the ultimate consumer or at wholesale to a distributor and the cost of delivery depends very largely on the method in vogue or proposed, but the greater cost of retail service is offset by a rate differential such that in the end earnings on the unit investment are not, in general, materially affected by the adoption of one rather than the other of these plans.

A transmission system may be considered to be composed of trunk lines, secondary lines and feeders. The cost of trunk lines depends primarily on the proximity of the power plants, principal and auxiliary, to each other and to the center of load, whereas the cost of secondary lines and feeders depends largely on quantity requirements, both as to capacity and period of use, or what is synonymous, the number of consumers served and the density of the market.

Secondarily the cost of transmission lines is affected by the relative importance of assured continuity of service and in addition the locality variable enters into the problem. Urban work, values of land, size of properties crossed and similar circumstances greatly affect the cost of lines. The rigors of climate, cyclones and the prevalence of electrical disturbance require careful consideration and arbitrary regulations as to structural details must frequently be observed whether the cost is justified or not.

Conductor cost should be balanced for permissible line loss at prevailing rates, and transformers, to prevent excessive core losses, should be so proportioned as to carry capacity loading as much as possible.

Fixed charges for distribution plant, based on right-of-way costs, leases or fees and equipment and structures costs may therefore also vary between very wide limits with perfect propriety.

Operating costs of the system depend on topography, multiplicity of lines, substations and terminals and their accessibility by rail or highway, weather conditions and special maintenance requirements for city lines, stream or railroad crossings.

Factors of Selling Price.—Selling price depends on either the cost of a competitive product or rates fixed by a regulatory body, i. e., in the last analysis, by the purchaser.

The competitive product may be either purchased electrical power or produced power. Regarding the practicability of competition with purchased power, there can of course be no controversy. However, the feasibility of building a water-power plant or system for the competitive sale of electricity with that otherwise produced is not always so readily established. The selling cost of high-load-factor power, produced in large volumes with fuel at reasonable cost, is not, in general, appreciably higher than that produced by water, if in the latter case the transmission cost amounts to much.

In small fuel plants, however, and particularly when operating at a low load factor, it is at the present time impossible to produce power at a cost as low as that at which reasonably near and economically developed water power can be delivered.

But the efficiency of water-power-plant equipment and the over-all efficiency of water-power production are already very high and only little improvement can ever be effected, while the efficiency with which fuel power is produced, both as to fuel transportation and conversion, is exceedingly low and great improvement may confidently be expected. Hence the present margin between selling costs of power produced by these several methods is not so great but that a pronounced improvement in the effective use of fuel may, in a great measure, jeopardize the investments made in water-power plants.

Effect of Public Utility Regulation.—To regulation we owe general recognition as public utilities and as such we are granted eminent domain for transmission-line rights of way, and sometimes for water rights. This means that we cannot be arbitrarily stopped from proceeding with certain plans of development and that we do not have to pay very much more for property rights and easements than the market value thereof.

The impression prevails that, under regulation, the income of a utility is guaranteed. This is an utter fallacy. The income is merely limited, and in too many cases unfairly limited. Within the last few years earnings on securities have in too many instances had to be paid out of funds which should properly have been devoted to maintenance, or possibly unwise curtailments have had to be made in personnel. Deferred maintenance is the most serious disease with which a utility may be afflicted.

Theoretically, regulation is not so bad because, to that extent to which it is insisted that a high standard of service shall be maintained without discrimination as to rates, it benefits those who conscientiously administer this industry. This, however, is practice or service regulation and not rate regulation. Where competition is free, economic law operates to prevent continued exorbitant profit taking, the art is developed, and progress is made. Particularly with the power industry would this be the case.

Bearing on this question, the following issues are important:

Permitted rates of return on investment are inadequate.

Certain otherwise irretrievable losses of income may not be covered by rates.

Certain non-insurabe risks may not be offset out of rates.

Unfair competition is not throttled.

Efficiency receives no reward.

A public utility that is not constantly expanding is decadent. New money must at frequent intervals be secured to finance extensions required from time to time, oftentimes under instructions of the commissioners.

In principle the returns on investment permitted under regulation are intended to be sufficient only for payment of interest and dividend, and for the perpetuation of the investment out of a depreciation reserve. The establishment of a sinking fund, out of earnings, is not proposed and borrowed money must therefore be kept in perpetuity.

It is of course both logical and proper that the depreciation reserve fund should be reinvested in the property to cover cost of extensions, but this money should be in the first place, under healthy growth, be inadequate, and furthermore, once so invested the resources of the corporation become so non-liquid as to expose the administration to considerable financial embarrassment in cases of emergency when immediate funds should be available. At such times the desperate need for money is naturally and not without warrant taken advantage of because credit has been impaired.

Composition of Financial Structure.—The financial structure which supports this industry is, in general, composed of:

A Lender: To whom payment of interest is compulsory under the security which he holds and which amounts to the entire property owned.

The lender sees to it that this is a safe risk. His criterion generally is that estimated net earnings shall be at least two times and generally two and one-half times the bond interest.

A Preferred Investor: In stock whose payment in dividends is substantially guaranteed under a lien subordinate only to the bondholders' equity. This investment is attended with all sorts of management and non-insurable structural risks.

A Speculative Investor: In common stock whose dividends are paid only if there is anything left over.

Customary and proper rates of return under respective security holdings may be set up as follows, based on the existing actual, not legal, interest rate tor short-term collateral loans of equal volume:

	Per cent				
Actual interest rate	4	5	6	7	8
Bond interest	5	6	7	8	9
Preferred stock dividend	7	8	9	10	11
Common stock dividend	10	11½	13	14½	16

One court held that the average rate of return on the entire investment should be 3 per cent above the existing interest rate.

The actual rate of return on capital ordinarily invested in any business enterprise is oftentimes lost sight of because it is confounded with the percentage of net profits made on units of output. If a turnover can be made four times in a year and a net profit of 6 per cent is made each time on the goods sold, the actual rate of return is 24 per cent and not 6 per cent. This is not at all an extraordinary performance.

A power plant is exceedingly fortunate if it makes a turnover once in four or five years. Returns permitted under regulation lie between 6 and 8 per cent. Some commissions may possibly, but not to our knowledge, allow more.

An ideal organization is one-third each of bonds, preferred and common stock and, with brokerage included as a capital cost, net earnings should be permitted as follows, as based on actual interest rates: 4 per cent and 7⅓ per cent; 5 per cent and 8.5 per cent; 6 per cent and 9⅔ per cent; 7 per cent and 10⅚ per cent; 8 per cent and 12 per cent.

When commissions arbitrarily fix a rate of return which is not in keeping with financial conditions, money must be secured from such sources and at rates such that interest payments will remain within earnings. The result of nonobservance of these fundamentals has been that utilities have been compelled to mortgage too large a part of their equities, bonded indebtedness has become dangerously great, and no new funds are available. Today permissible earnings are, in general, insufficient to attract new capital.

Unrecoverable Losses.—Based on the law that utilities should not make unjust profits, it should equitably follow that they are entitled to protection against unjust losses. In financing such undertakings reliance is placed on constancy of return and rates are predicated on probable normal output. Industrial activity, however, varies in cycles and a falling off of normal business cuts into earnings in a manner which cannot be guarded against because, in general, equipment capacity kept in readiness to serve under contract provisions cannot be otherwise put to work. Contract minima, ordinarily, assure nothing more than the earning of bond interest alone.

Losses of output and therefore earnings are sometimes seriously affected by storm or flood conditions, against which the property cannot be guarded. Fire and breakdowns may, without fault on the part of the operating personnel, render normal service impossible and emergency service under any of these conditions is apt to be very expensive, but nevertheless practically obligatory. Interference with business by strikes, declaration of martial law, etc., mean unavoidable loss of income.

Against none of these contingencies can the management protect itself as this is customarily done and essential to safe business conduct, i. e., by the setting aside of a contingency or, as it has been called, a "stabilization," fund.

As to water power particularly, a development condition prevails which must be taken into account. The cost of prime movers is almost invariably only a small percentage of the total cost of all structures which must be completed in order to be able to manufacture any power whatever and the progressive development of the plant to meet the growing requirements of the market is more or less impracticable. Overdevelopment, therefore, is the rule, and since, for purposes of rate fixing, earnings are predicated on possible output instead of on probable demand, certain losses of income occur during the period required to bring sales up to the developed output capacity.

Under these unalterable circumstances the loss of earnings which are necessary to offset interest and dividend payments and the setting aside of funds to cover a depreciation which is actually going on, may legitimately be treated as development costs, either to be included in the capital cost on which the rate of return is based, or otherwise covered in the rate composition. One court, however, has held that any compensation for business losses in the adjustment of rates leads to a "reductio ad absurdum."

Quite enormous losses have been incurred by power companies due to great delay in the granting of those higher rates which the commissions by their own rulings have established as having been justified. Such requests of course grew very largely out of increased operating costs and to that extent to which they represent operating costs only and not the earnings of capital invested during the period of high prices, a future reduction in rates is to be expected. It remains to be seen whether it will be permitted that losses already sustained can be recouped before reductions in rates are ordered.

Floods may destroy dams and cause tremendous damage to persons and property. Lightning may burn up transformers and other equipment. Falling trees, wind or sleet storms may cut transmission lines in two and by short-circuit magnify the direct damage. Death-dealing currents take their toll of life regardless of even extraordinary precautions and, while such a risk is insurable, the amounts involved are limited and in any event defense in litigation is very costly.

Premature destruction of structures and equipment is not covered by the depreciation reserve and accidents requiring the outlay of additional capital without a corresponding increase in earning capacity can be covered only by a contingency reserve, provision for the accumulation of which should be included in the rate structure.

The antiquation or obsolescence of parts or even the whole of the plant through the possible development of novel equipment or methods for power production at lower selling cost than that possible with equipment now available or even by water power at all, is not too remote a happening to be given consideration, and this contingency should, in a measure at least, be offset by liberal present earnings.

That efficiently operating public utilities promote the welfare and growth of any community is obvious. If, therefore the regulatory bodies would take a proper pride in the efficiency of the utilities which they regulate and would d everything to make it possible for the companies to deliver on sound financial bases the best service at the lowest rate, they would be doing their communities a signal service. Also in order to allay much of the antagonism toward public utilities fostered by political attacks, regulatory bodies should demand of all utilities under their jurisdiction, including the municipal plants, a uniform system of accounting such as to expose many of the fallacies now entertained.

Rates for electrical current are presumably based on cost of the service, painstakingly predetermined for each particular case. Cost of service is, however, susceptible to considerable modification depending on the degree of efficiency attained in administration of the property. If earnings are absolutely limited, the incentive to efficiency is lost and that is one of the most discouraging features of rate regulation. Zealous communism is only a theory.

A Concise Schedule of Economic Considerations.—Having in broad terms indicated some of the more vexing problems that confront the industry, an attempt will now be made to present as concisely as possible a schedule of economic considerations, the observance of which may lead to more satisfactory solution of these problems.

AS TO THE PHYSICAL STRUCTURE.

Design and Construction of Plant.

1. Thorough Preliminary Study.—Geologically, meteorologically, legally and commercially. Such study requires time and money and both are too often curtailed.
2. Control of Entire Stream.—To make regulation most effective and to prevent competitive injury.
3. Degree of Stream-Flow Utilization.—The extent to which secondary power may be developed for sale or conversion into primary power.
4. Best Use of Land or Water Rights.—Mechanical or automatic pond-level control to maintain a maximum head.
5. Plan of Development or General Layout.—Location, utilization of site, (extent, method) progressive construction and stream regulation, location of auxiliaries, territorial control of market.
6. Type of Structures or Detail Layout.—Kinds of dams, character of water channels, equipment setting, equipment housing, effective design for tail race, use of adjunct equipment, and belt-transmission trunk lines.
7. Type of Equipment.—Prime moves suitable for characteristic load and service. Effective accessories. Adequate recording instruments, high-efficiency draft tubes and use of ejectors or tail-water elevation control. Air coolers for generators. High-potential generation or transmission. Automatic or semi-automatic generating stations and substations.

Selection of Auxiliary Equipment.—Ordinarily this should be high-capacity, quick-response, equipment of low first cost. Dependability is much more important than economy of operation, although low attendance costs are to be attained if possible. For this purpose there are best adapted steam turbines and boilers equipped with mechanically atomizing oil burners or powdered-coal-burning equipment. Heat balance is of secondary importance. Electrically operated auxiliaries are better for quick starting.

8. Capacity of Equipment, Unit and Total.—Adaptability for characteristic load changes. Maintenance of balance, large and small units. Amplitude of reserve capacity. The cost of prime movers alone is generally only a small proportion of the total development cost and sufficient spare capacity should be installed.
9. Economical Construction.—Effective building organization, executive, clerical, supervisory. Conscientious inspection. Economical purchasing. Reduction of unproductive construction period to the economical minimum. Assurance of service continuity by careful testing out.
10. Interconnection between power systems.

AS TO THE PRODUCTION STRUCTURE.

Operation of Plant—Production and Distribution—Routine.

1. Regular inspection and tests; owner's installation and customer's installation.
2. Effective service records and accounting.
3. Proper use, maintenance and loading of equipment.
4. Maintenance of balance between water and auxiliary power. Assuming storage to exist, it is generally best when an auxiliary plant requires operation, to operate it at full load, taking peaks on the water-power plant.
5. Fuel-efficiency control. Volume purchase by combined interests on specification basis under strict supervision.
6. Perfect load dispatching based on meteorological observations.

Administrative.

1. Proper selection of employes.
2. Education and training of employes—general, specific. Explicit written instructions should be furnished each employe setting forth his duties, methods of accomplishment and reasons for performance. Maintenance of discipline.
3. Development of loyalty and co-operation in employes. This may be brought about by fair dealing, manifest integrity of purpose, welfare work, encouragement by public recognition of especially meritorious service, appreciative adoption of suggestions and partnership in the business which should be made easy.
4. Acquirement of expert detail knowledge of the business in a manner to make information instantly available for effective analysis and synthesis.
5. Research and investigation to perfect methods which information should be co-operatively interchanged.

AS TO THE COMMERCIAL STRUCTURE.

Selling the Service.

1. Perfection of service.
2. Saturation of system; development of rural loads.
3. Selection of load. While the service requirements in a given market are quite characteristic, some improvement is generally possible. The diversity factor may be improved, the maximum demand may be cut down and the load factor may be raised by the encouragement of off-peak loading. Electrolytic processes, electrical industrial heating, domestic use of heat in all manner of appliances, and off-peak pumping and similar intermittent service suggest themselves as desirable loads.
4. Protective contract provisions.—Service classifications, unavoidable interruption of service not to be penalized, maximum demand limitations, power-factor penalties and bonus, fuel clauses, agreement to pass along extraordinary taxes, cost-of-living adjustment.
5. Classified service accounting to detect inadequacy of certain rates.
6. Development of a sympathetic, understanding attitude in consumer by intelligent publicity and helpful advice as to proper use of current and equipment.
7. Avoidance of too preponderant a load from either one or just a few consumers or either one or several closely allied industries.

AS TO THE FINANCIAL STRUCTURE.

Providing Funds.

1. Balance in equities of classified security holders.
2. Adequate working capital provisions.
3. Bond issue under a series mortgage.
4. Consumer partnership.
5. Reinvestment of depreciation reserve.

In all of the above it must be remembered that small plants require different treatment from that accorded to big plants and that isolated plants must be quite differently planned from those forming part of a chain or system.

In the light of what has gone before the question as to whether water-power development is a paying proposition may now more intelligently be answered.

Water-power development does pay—never big, however, but even very small plants of high unit cost entirely justify their existence. It does not pay at this time because the public will not invest in securities at interest or dividend rates which permit the financing of such undertakings on a basis of present permissible earnings.

However, these facts notwithstanding it is a gloriously constructive work and, because of the individuality of each project and the ever present hazard, it certainly may be ranked as the greatest sport on earth.

Water Treatment on Missouri Pacific R. R.

Water treatment on the Missouri Pacific R. R. in 1921 resulted in a net saving of $443,369, according to a recently compiled report of the water service branch of the railroad. The 77 treating plants on the system, including ten placed in service last year, treated 1,781,560,000 gal. of water from which 4,916,247 lb. of scaling solids were removed. On the basis of 13c as the conservative estimate of the savings per pound of scaling solids removed, there was a total saving of $613,964. From this should be deducted $170,575 for the cost of treatment, supervision and depreciation of plants, leaving a net saving of $443,369, or a return of 143 per cent on the $309,611 invested in treating facilities.

The total consumption of water on the system during 1921 was 5,948,117,000 gal., of which 5,153,024,000 gal. was used for making steam. Of this latter amount 34.6 per cent was treated. The average cost of treatment in 1921, including operation, supervision and 10 per cent depreciation, was 9.8c per 1,000 gal.

It is estimated that the removal of these solids from the water resulted in a saving of approximately 5 per cent, or 62,000 tons, in coal consumption, while the records show that the life of flues and fireboxes has been more than doubled in many districts since treating plants were installed and that delays to traffic from engine failures due to boiler troubles have been reduced from 30 to 60 per cent.

Treatment of Hard Impure Waters with Alum

Action of Aluminium Sulphate in Water Described in Paper Presented May 13 Before Canadian Section of American Waterworks Association

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The art of treating water with aluminium sulphate ("alum," for short) for purposes of coagulating the impurities of color, turbidity or micro-organisms, in order to condition it previous to filtration or to settlement with or without filtration, is essentially experimental. In spite of the many researches that have been carried out into the problem, no one can at present determine the necessary amount of alum or the time required for the reactions to take place or the amount of residual alum in the filtrate in any given instance from a mere study of the salient characteristics of the water. This situation arises from the multiplicity of the important factors involved, and their interactions are such that in practice the problem becomes too unwieldy. Nothwithstanding this, great strides have been made in the study of the problem by various methods and a number of mile posts have been fixed along the road towards the complete solution of the problem.

Effect of Increased Bicarbonates in Water on Alum Dose.—In the treatment of drinking water with alum, the alkaline bicarbonates of calcium and magnesium existing naturally in the water are relied upon to decompose the alum in solution and to form insoluble aluminium hydrate, which is the active agent of coagulation; and as these bicarbonates are almost always present in abundance in hard waters, there will always be sufficient present to satisfy the chemical requirements of this reaction. This was practically all the text on the subject at one time considered to be necessary. But a little practical experience shows this to be by no means the case.

General experience has shown, and it has been confirmed in systematic experiments by Morison[1], Pirnie[2] and others, that increased quantities of bicarbonates in a water demand increased quantities of alum to treat it, and, as might be expected, the same applies to increased contamination and turbidities, but the law of increase is different in the two cases. In the former the action is often, although not always, such as would be expected if a certain amount of the alum floc went into solution or in some way failed to precipitate, and in the latter case the results are so very uncertain because of the uncertainty of the nature of the contamination. As an instance of the difficulty of estimating the effect of a contamination, it has been found in laboratory experiments that one part in a hundred million of gelatine dissolved in Lake Ontario water made coagulation exceedingly difficult.

Some interesting laboratory experiments on the effect on visual precipitation of clay and silica turbidities of various mineral salts when treated with alum have been made by Smith[3]. This visual effect, although somewhat different from the complete process involving filtration, does show that each substance has an effect of its own, and demonstrates how difficult must be the problem of predetermining the alum treatment for a natural hard water which contains many mineral matters. It is interesting to note that soda ash, which has been used as a corrective for acidity in the alum treatment of very soft waters, showed a distinctly inhibitive effect on the clarification of the water by alum. The same applies to the bicarbonate of soda and most sodium compounds; in fact nearly all substances experimented with had an undesirable influence on final clarification.

Optimum Amount of Alum Increases With Alkalinity of Water.—Closer studies of precipitation in the light of colloid chemistry have shown that the process goes through various phases as the application of the alum is increased, and the experiments of Morison[1] previously referred to are exceptionally interesting in this particular. They show clearly there is an optimum amount of alum which increases with the alkalinity of the water; and, in addition, that coincident with the optimum amount of alum, no residual alum was found in the supernatant liquid but was found there at every other concentration. In these experiments the optimum amount of alum runs rather less than half the equivalent alkalinity, and it would be interesting to know if this relation is always the same.

The question of the existence of alum in filter effluents has been closely studied by Howard and Hannon and Wolman[7], who have found that effluents from all treated waters examined gave residual alum reactions. In the case of Lake Ontario water at Toronto, it was demonstrated that the residual alum after filtration was a hydrate in colloidal form which subsequently became an aluminate the exact nature of which has not been determined.

Stein's[8] experiments on the removal of tannic acid color by alum cover a wide range of both acid and alkaline waters and show with the latter waters that aluminum hydroxide, although actually formed, is inhibited from precipitating by the tannic acid until an equivalent amount of aluminium hydroxide has formed, and this part of the subject has been worked out with considerable detail and should prove invaluable to filter operators.

Principles Underlying Coagulation.—Very few of the reactions that follow from the laws of ordinary chemistry take place in their entirety, or some of the expected precipitates do not show up in whole or in part. This is particularly noticeable in the weak solutions of chemicals used in the treatment of drinking water, and colloid chemistry treats of this branch of the subject. In the purest of pure water, about one in every six hundred thousand of the water molecules appears to be broken up into two fragments, one hydrogen nucleus constituting one fragment, and one hydrogen atom, one oxygen atom and one electron constituting the other fragment. These fragments of the molecules remain in the water in a peculiarly active state, in which they are said to be electrically charged, the exact meaning of which, however, is not completely understood. In this state the separate parts into which the molecules are broken up are called "ions." The hydrogen nucleus ion is described as positive and the remainder of the molecule negative.

The electrical explanation given is that a positive ion contains one electron less than is necessary for stability, and a negative ion one more electron than is necessary for stability. Thus the one contains an excess of that energy which the other lacks, and to the same extent. If a simple acid be added to this pure water, the amount of the dissociation increases, and, if on the other hand, an alkali be added, the dissociation decreases.

This is the simplest possible abstraction of the principle underlying coagulation. The impurities in the water such as can be removed by coagulation and filtration appear to be ionized. The same applies to some extent to any and every substance dissolved or in suspension in the water. The removable impurities may be, and generally are, considerably larger than the molecular size, and consist of groups of molecules which in an ionized condition will remain suspended in water indefinitely by reason of their mutual repulsions, and, to some extent, by that form of energy known as Brownian movements, unless some change is made by which the ionization can be neutralized or balanced in some way by the addition of the proper ingredients in which the ionization is of an opposite character. In hard waters the ionization of the impurities is negative to that of aluminium hydrate precipitated from solution as described above, and thus coagulation takes place as the neutralization proceeds.

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[2] Pirnie, M Application of Colloidal Chemistry to Study of Filter Effluents. Journal Amer. Water Works Association, Vol. IX., No. 2.

[3] Smith, Otto M. The Removal of Clay and Silica from Water. Journal Amer. Water Works Association, Vol. VII., page 302.

[4] Howard, Norman J. Description, Operation and Purification Effected by Drifting Sand System in Toronto During 1918. Journal New England Water Works Association, Vol. 32, No. 4.

[5] Howard, Norman J., and Hannon, F. Alumina Hydrate in Mechanically Filtered Water. "The Canadian Engineer," May 13, 1920.

[6] Howard, Norman J. Statistical Record of Toronto Water, 1912-22. "The Canadian Engineer," May 9, 1922, page 469.

[7] Wilman, A., and Hannon, S. Residual Aluminium Compounds in Water Filter Effluents. Chemical and Metallurgical Engineering, Vol. 24, No. 17, April 27, 1921.

[8] Stein, Milton F. Some Notes on the Colloidal Chemistry and Water Purification. American Water Works Association, Vol. VII., 1921, page 571.

The act of catching the impurities by the alum is the fundamental point of coagulation and must not be confounded with the precipitation which follows it, and one must guard against the assumption that the water which visibly flocs the best will produce the best results when filtered. Sometimes this is certainly not the case. Unless the impurity is caught before filtration, very little prospect remains of it being caught at all. In laboratory experiments the mixing of the solution of alum with the water can always be carried out quickly, but not so in practice, where it is quite possible to find the reactions progress far too quickly for the best results. In some very few instances, however, it has been reported that hours, or even days, may elapse before the reactions are complete. Of these the writer has had no experience, but in any event in such cases it would probably be desirable to condition the water before treatment with the alum.

Hydrogen Ion Concentration as Measure of Amount of Alum Required.—The nature of coagulation being closely associated with the hydrogen ion concentration in water, it has recently been suggested that a measure of it in water might be used to determine the necessary amount of alum to be employed and otherwise control the whole purification process, and some considerable progress has been made in which Hannon[7] at the Toronto Filtration Plant, in collaboration with Wolman, has done most important work. Hannon has shown that the precipitation effects do vary with the hydrogen ion concentration, but that with Lake Ontario water the alkalinity is too high to reach the optimum, or isolectric point as it is called, with a reasonable amount of alum treatment alone, but this point has been approached by the application of mineral acids to the water. This, of course, might not be permissible in practice, but the application of carbonic acid, if it can be dissolved in the water, would be more effective and practical. This, however, could easily be applied in the much-maligned pressure filters with ease by maintaining an atmosphere of the gas in the filter.

The same end can be obtained by reducing the alkalinity of the water by softening, and a third method is to drive hyrdogen ions into the water by electrolysis. There is in this method of controlling the purification of the water the possibility that the most effective hydrogen ion concentration floats about with the nature of the water.

It is, however, possible that a careful study of a particular water by this method may lead to some correlation regarding it and the alum requirements. In any natural water the variation in the hydrogen ion concentration is almost invariably due more to changes in the carbonic acid content than to anything else, as may be noticed by the considerable change in it due to filtration or to the treatment with alum, which, while reducing the alkalinity, increases the carbonic acid.

In the case of Lake Ontario water at Toronto, Howard has found that the most certain index of the amount of contamination in the water and the corresponding alum requirement is the amount of free ammonia present, but no definite scale of relationship has been established, and seasonal changes appear to have a very considerable effect; but this seasonal effect is probably due to changes in the carbonic acid content.

Smith has shown that the treatment of a hard water with alum is greatly simplified by softening the water with lime applied slightly in excess of the amount necessary to produce the minimum hardness, and quotes the case of Little Rock, Ark., as a satisfactory example. It also corresponds with experiments known to the writer on the reduction of color in the Otonabee River water. It also corresponds with the laboratory experiments of Morison[1] and Pirnie[2] and the hydrogen ion concentration.

Summary of Conclusions.—A hard water invariably contains an excess of the necessary ingredients for decomposing the alum, but a trace of some form of aluminum remains in the water after filtration in the form of an aluminate except at one critical concentration, often too far removed to be realized in practice. Every substance in the water, whether dissolved or suspended, has an effect upon the amount of alum required, and generally the higher the amounts of mineral matter and the harder the water the greater will be the need of alum to coagulate the impurities.

The necessary amount of alum or the proper treatment before adding the alum can be determined only by experiment.

Gelatinous compounds in hard water seriously inhibit coagulation.

The time required for the reactions to take place is mostly short, approaching the instantaneous and in some cases too short for the best results unless specially rapid means of mixing are adopted. In a few rare cases the reactions extend over a period of hours or days. In such cases special treatment becomes desirable.

In Lake Ontario water in the absence of considerable turbidity the free ammonia content is the best index of the contamination and corresponding alum requirements.

The study of the hydrogen ion concentration has been suggested as an index of the amount of alum required, and some forward steps have been made by this means.

If the hydrogen ion concentration of a water is a measure of the condition of that water for treatment with alum, then we might expect the presence or absence of free CO_2 to have a most important effect upon the problem.

Filtering in pressure filters in an atmosphere of CO_2 might be expected to bring the hydrogen ion concentration up to the isolectric point with care and certainty, but the probability of corrosive effects would be increased.

Softening the water with lime has much the same effect.

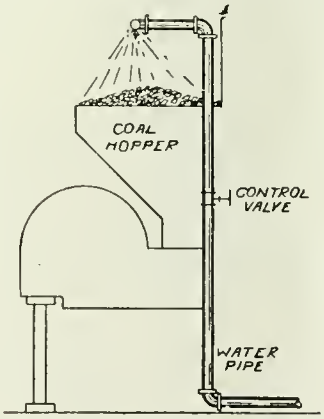
Forcing charged hydrogen ions into the water would temporarily (at least) also have the same effect.

When the isolectric point is reached, there is little or no residual alum in the filtrate, and the application of the alum is efficient.

Filtering water always raises the hydrogen ion concentration by forcibly separating the parts of the water molecules in compliance with the better known principles of contact electricity, but returns to nearly its former value if the water is allowed to remain in contact with the air.

A Good Way to Wet Down Coal

A novel method of wetting down coal employed in a plant using a good grade of coal, but one that runs high in fines, is described by R. K. Long in Power Plant Engineering. This method consisted of wetting down the coal immediately before it went to the furnace instead of wetting it down before it went into the coal hoppers above the stoker hopper, the customary practice. A small pipe was installed along each boiler and a perforated pipe located horizontally above the stoker hopper, as shown in the accompanying illustration. A valve alongside the stoker speed control enabled the rate of water flow to be regulated.



Piping Arrangement for Wetting Coal in Hopper.

The reason that this arrangement appeals as being particularly interesting and perhaps worthy of being passed along to others is that watering the coal in this way permits close control of the water content added to the fuel; the fireman will attend to this matter more closely than the laborer. The operation becomes automatic. Any trouble that occurs, due to coal sticking in the chutes, becomes less likely when dry coal is used instead of wet coal. Coal is slightly corrosive when dry, perhaps; it is very corrosive when wet. Wetting the coal immediately at the stoker hopper instead of before it enters the coal-conveying machinery and main coal hopper means that whatever corrosion is due to wetting will occur at the stoker hopper. Corrosion will be confined to a small area and to a piece of equipment that is comparatively cheaply and very easily replaced. These advantages are worthy of consideration.

Going a little further, it might be worth while to use hot instead of cold water for wetting down. There is generally plenty of hot water going to waste. Every degree of temperature increase of the water used for wetting down means that much less heat required later to be extracted from the furnace to heat and evaporate the water. The use of hot water is thus a direct gain. Corrosion would, however, be somewhat accelerated, but not enough to offset the benefit of hot water.

How to Get Better Boiler Room Operation

Methods of Large Company Described in Paper Presented Before Stoker Manufacturers' Association

BY C. W. DE FOREST

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The boiler room is only one of the links in the chain of operations involved in transforming the energy stored in our coal resources into the electrical energy furnished to consumers. During the recent past, the attention of engineers has been frequently called to the fact that the efficiency of modern boiler room practice is very much higher than the efficiency of producing and mining coal, and of converting the energy of the steam into electrical energy. It might seem, therefore, that attention should be concentrated particularly upon those links in the chain of operations involved in transforming the latent energy of coal into electrical energy available to consumers, where the greatest returns can be obtained from a given expenditure. But while this is true, and is becoming more and more apparent, it can be shown that the possible increase in efficiency in many of our boiler plants, more than justifies the necessary expenditure involved.

Factors Entering into Cost of Production.—Let us first consider the necessity for better boiler room operation. We can do this by briefly reviewing the principal factors which go to make up the cost of producing electrical energy, from the coal pile at the generating station to the bus bars.

The three principal factors entering into the cost of production are:

(1)—Investment cost;
(2)—Cost of fuel;
(3)—Organization, personnel, supplies and maintenance costs.

To simplify our problem, we may leave the first factor out of consideration, and assume that the plant and equipment are properly designed and installed.

Fuel Cost Largest Item.—Let us suppose that we have a modern station of about 100,000 k. w. capacity, consisting of turbo units of from 20,000 to 35,000 k. w. each, and a boiler plant equipped with boilers each of 1,000 rated h. p., or larger, operating at steam pressures of 250 to 300 lbs., and a total steam temperature of from 600° to 700° F. Such a plant, with good load factor, should have a station water rate of 12 lbs. per k. w. h. What are the factors which determine the unit cost of energy? Table 1 shows how the various factors involved enter into the total cost.

TABLE 1.

	Percent of total cost per K.W.H.
Superintendence, Clerical and Efficiency Dept.	2.00
Boiler room operation, including ash disposal	5.12
Boiler room repairs	3.80
Engine room operation, including electrical	4.60
Engine room repairs	3.07
Miscellaneous expense	4.61
Coal at $1.00 per ton	76.8
Coal at $5.00 per ton	80.5
Coal at $6.00 per ton	83.2

From Table 1 we see that the fuel cost at $4.00 per ton is 76.8 per cent of the total; at $5.00 per ton, 80.5 per cent; at $6.00 per ton, 83.2 per cent. These figures are for a plant capacity factor of 41.2 per cent. As this factor is increased, the percentage of cost per k. w. h., due to fuel will increase. These figures should bring out clearly the necessity for continued effort to secure better boiler room operation. Where the cost of producing a k. w. h. is higher, the necessity for saving will be more apparent.

Of course, there are three distinct elements which determine the coal per k. w. h. This first transfers the energy of the coal into steam, the second transfers the energy stored in the steam into mechanical energy at the turbine shaft, and the third changes the mechanical energy at the turbine shaft into electrical energy at the generator terminals.

Factors in Cost of Boiler Room Operation.—Given turbines and generators of definite characteristics, it is comparatively easy to watch operations and to make the necessary adjustments to maintain satisfactory operating conditions. But the first factor, that of producing the steam, which represents from 76.8 per cent to 83 or 85 per cent of the total cost, is carried out under conditions that are constantly changing. The losses taking place are doing so minute by minute and like "Water through the mill," once lost, cannot be recovered.

The art of fuel burning has made great advances in practice, in the past ten years power station management is recognizing the necessity of equipping the boiler plant with suitable instruments to enable the combustion engineer to know what is taking place in the furnace and throughout the heat-transfer equipment. But the mere installation of instruments does not result in the saving of a single pound of fuel.

Let us review the factors entering into the cost of "Boiler Room Operation." Table II shows a typical "Set up" of the gross cost of boiler operation.

TABLE II.

	Cost per month.
Stoker engineers and firemen	$1,980
Water tenders	420
Heater tenders	378
Economizer tenders	624
Oiler	120
Instrument attendant	240
Relief men	284
Blowing soot, boring tubes, inspection, cleaning boiler room and apparatus	1,600
Proportion of time of assistant to superintendent and chief engineer	150
Total cost boiler room operation	$5,796

The above table shows that the cost of stoker engineers or firemen, including the time of the assistant superintendent, actually given to boiler room operation, is only $2,130 per month, or 1.55 per cent of the total cost of power house operation, and including the total cost of superintendence, clerical work and efficiency engineer, charging all of the cost to the boiler room, is only 3.25 per cent of the total cost of power house operation.

Five per cent variation in furnace and boiler efficiency represents quite a sum per year; with coal at $5.00 per ton, it amounts to $70,000; even 2 per cent amounts to $28,000.

The only way to gain that last 2 to 5 per cent in boiler efficiency, is by constant, efficient watchfulness on the part of the stoker engineers, boiler room foreman, and the efficiency engineer, and we cannot afford to employ cheap, inferior men in the boiler room.

Training of Firemen.—In order to get results, we must have the real, genuine co-operation of the men. They must be personally interested in their work and the results of their work, and to obtain this end, the conditions under which they work must be pleasant, their wage must be adequate, and they should be kept in touch with the results of their work.

Our company does not hire experienced firemen. We try to select clean, bright men, with brains, regardless of former experience in the boiler room. In fact, we frequently find, the less experience they have had, the less we will have to overcome. Upon employing a man, he is put in as boiler room helper, then economizer tender, heater tender, boiler maintenance work, and finally on stoker operation or firing.

We conduct two classes a week, at different hours, which it is compulsory to attend. The men are taught the principles of combustion engineering and elementary mechanical engineering, as especially applied to the equipment in our station.

Boiler Room Instruments.—The instrument equipment enables us to have a full knowledge of draft conditions and temperatures throughout the furnace, boiler and economizer, steam flow on indicating and integrating meters, pounds and quality of coal used by each boiler and by sampling and analysis, the amount of combustible in the ash. All instruments are carefully maintained and the records carefully compiled daily. After these records are obtained, they are carefully analyzed, and every effort is made to apply the information thus recorded, to maintain our highest standard of performance and, if possible, improve it.

Each day we know the efficiency obtained by each boiler and the general performance of each pass and part of the boiler, from the furnace on up through the economizer. This information is compiled in useful shape daily and checked by the Efficiency Engineer and the Superintendent of Production.

and readily shows any furnace, boiler or economizer that is falling off in efficiency, as well as the reason for this condition.

By proper management it is not necessary to use the time of the engineering staff for the detailed routine work of preparing the data for use. The work of planimetering the records and entering the results in proper form on the daily performance record is practically all done by one woman. We have tried men, but usually young men with the required mental equipment will not remain on work of this character as, naturally, they want to progress, but a woman will stick to it except for a wedding, and girls are more deft and soon become expert. The nature of the work is such that it is not difficult to train the kind of woman who is capable of high-grade stenographic work, but in the selection due regard should be given to those possessing mechanical tendencies.

I would rather keep too many records than too few. The total cost of our record work, including the electrical daily log sheets, records of feeder output and complete turbine-room and boiler-room records, including stationery and forms, is $7,700 a year, and what business totaling $1,800,000 per year expenses would not spend more than four-tenths of one per cent for accounting and cost keeping, particularly when it is one of the vital factors in maintaining standards of operation. Satisfactory operation is not usually secured by using the time of engineering talent at desk work. We find that the best results are obtained when our engineers are out in the boiler room, applying the information to get results. Boiler-room records and accounting can be as readily kept as cost records in any other business.

If we expect to keep a boiler plant up to an average efficiency of from 75 to 80 per cent the boiler plant as a whole must be well maintained. How often we find that equipment will give high economy when new, but that the efficiency drops off after a year's use. It is needless to go over the long list of conditions in a boiler plant that must be looked after. But manufacturers know from long experience, that apparatus will usually meet your guarantees when new and tested by your own engineers, only to fall off when left to the care of the station operators. From this it is apparent that lack of proper maintenance inevitably involves inefficient operation, and that the fault generally lies with the operating force, or the management.

Inspection and Maintenance of Equipment.—The modern power house, with its multiplicity of auxiliary apparatus, and being worked at increasingly higher stresses, cannot be left to haphazard inspection and maintenance. It is beyond the realm of possibility to expect any engineer or foreman, however conscientious he may be, to remember, in detail, when different apparatus was inspected or repaired. Record filing systems have been devised for performing this function, and it has been demonstrated that they are less liable to error than the most conscientious employee. It is not sufficient that a record be kept of when repair work was performed. A system must be used to insure the regular periodic inspection and maintenance of every piece of equipment.

The scheme we have adopted is to have a card for every boiler, stoker, economizer, motor, pump, all principal valves, switches, cables and every other separate piece of equipment. These cards show the principal data for the equipment as number, capacity, etc., the period of inspection, whether one week, one month or two months.

They are kept in a file, arranged according to date and distributed so that a certain number of cards are handled each day. One man is responsible for the proper handling of the cards and work orders. Each day, the cards covering the apparatus to be inspected, or repaired, are taken out and a specific work order issued for each piece of equipment, a perforated stub, bearing the same number as the work order, is retained by the maintenance clerk. The work orders are then given to the Chief Engineer for distribution to the proper foreman and repairmen. After the inspection, or repair, is completed, the work orders are filled out, showing the work done, amount of time spent on the work, etc., and returned to the Chief Engineer, who personally inspects the work to see that it has been done according to the order. The completed work orders are then returned to the maintenance clerk, and verified with the stubs. By this arrangement, the Chief Engineer and his assistants can use their time most effectively—no filing system can perform this function.

This system has enabled us to keep our equipment in good condition.

The Use of Compressed Air in the Ground Work of Public Utilities

The large, wire using public utilities have built immense plants in the last quarter century. These consist of pole lines, underground subways, central stations, sub-stations and shops, with all the transportation agencies involved in enterprises of such magnitude. The working organizations have been handicapped by working under the urge of a demand for service that was increasing. Under such conditions the staff end of the organization could not study the improvement of all methods, but concentrated on the production processes which were more vital than those of distribution.

In the more recent period, as the finance of the plant devoted to transmission and distribution has involved more consideration, research has scrutinized this field, and has found that much of the mechanical work in excavating both for subways and pole lines and the erection of poles, can be materially assisted by the use of power tools. In addition to this work, there are many jobs of a specialty nature on which such tools can not only materially assist, but do cleaner and more effective work than hand labor.

Large wire using utilities have extensive subway plants, portions of which were designed so long ago that they are outgrown and require alteration. The character of districts has changed, making desirable the substitution of underground distribution for aerial, where the pavements have already been laid. The substitution of gasoline driven for animal transportation has multiplied the pavements, increased their thickness and stimulated ingenuity in devising ways to place conduits without disturbing pavements.

Work on Which Portable Tools Can Be Used.—Among the tasks where portable tools are promising may be listed the following items:

1. Excavating holes for overhead lines, including anchor holes.
2. Setting poles.
3. Setting anchors.
4. Drilling ledge rock for setting poles, or excavating subway.
7. Cutting concrete or brick for subway alterations for rehabilitation to accommodate other utilities, such as sewers, gas or water pipes.
8. Driving the sheathing necessary in deep excavations.
9. Cutting iron pipes when involved in subway alteration.
10. Cutting iron pipe conduit on poles or buildings when badly corroded and needing replacement.
11. Cutting foundations of buildings, weighing pits, underground manholes—when making subway entrances.
12. Extending pipes from:
    One building to another.
    Subway to building.
13. Extending pipes:
    Underneath tracks.
    Underneath pavements, concrete or other hard surfaced highways.
    Connections from manholes to sewers.
14. Trenching in hard pan.
15. Cleaning concrete surfaces when making subway alterations and cleaning and painting metal surfaces.

Machine for Digging Pole Holes and Setting Poles.—One of the large, wire using utilities has recently placed in service a handy tool called a grunter. It consists of a 2½ ton truck, carrying:

Engine and air compressor. Displacement, 80 cu. ft. per minute.
Tank, capacity 60 in x 20 in.
Oil separator.
Manifold with three valves.
Air cylinder hoist.
Derrick.
Rotary air drill.
Earth auger.
Rock drill.
Air grinder.
Pneumatic hammer for chipping.

In operation for digging holes, the rotary air drill carrying the earth auger, is suspended from the boom by a line extending to the piston of the cylinder hoist. The rotary drill is, of course, connected by a hose with one outlet of the manifold. The operator, working with an assistant who manipulates the valves of the hoist, sets the auger over the stake and turns on the air. The auger rotates until it has cut its way into the earth far enough to be full. It is then raised by means of the hoist. The derrick boom is swung slightly and the auger dumped. The operation is repeated until the hole is of the required depth. The drill and auger are then unhooked from the hoist line. The line is attached to the pole, and the pole raised into place.

This machine is flexible and digs well in different kinds of soil. It was purchased after a demonstrating machine had excavated about 1,500 holes, about 100 of which involved rock drilling.

An illustration of the utility of the device occurred at the time of a recent storm break. It excavated 26 holes between 9 P. M. and 6:00 A. M. during a hard rain. There were plenty of men on the job, but the ground was so hard that they could not make progress, and the rain was very annoying. The men were, therefore, relieved and all of the work was done by the machine.

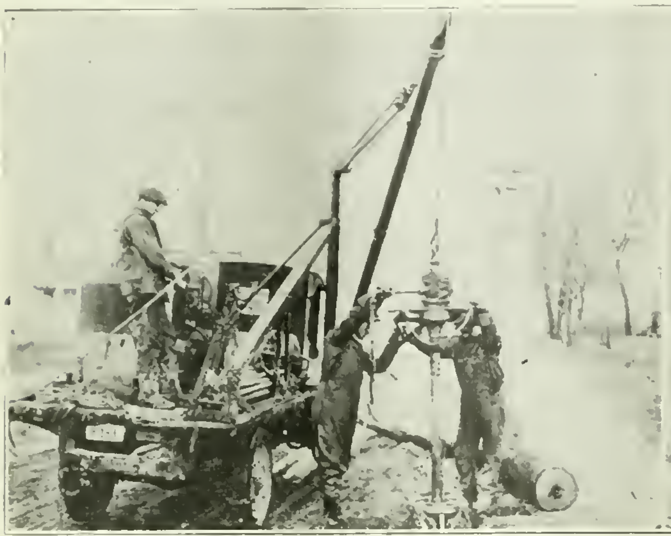
Fig. 1—Little Giant Air Drill Rotating Earth Auger.

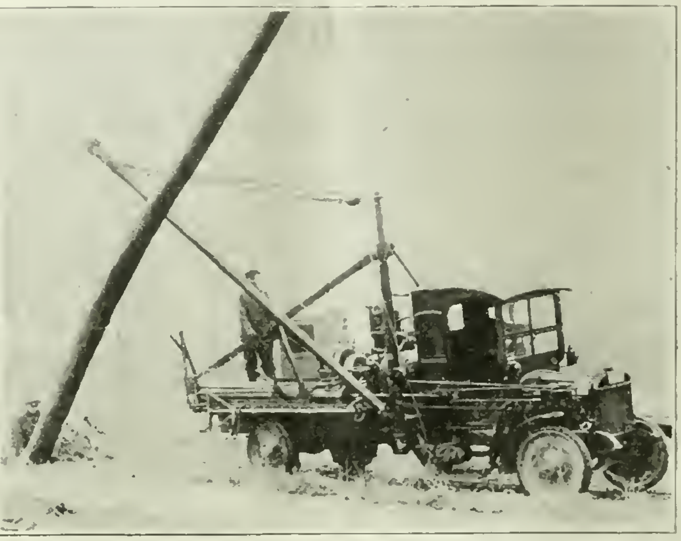
Fig. 2—Truck Mounted Air Hoist Hoisting Pole Into Position.

Besides digging pole holes and erecting poles, the demonstrating machine has been employed on a number of tasks of a specialty character, which we will describe:

Cutting Through Frost for Driving Well Points.—A number of subway manholes in the Calumet districts, near Chicago, had defective bottoms, which allowed water to run in as fast as it could be pumped out. It was planned to drive well points, drain the surrounding soil to the required depth, construct the new bottom and fill the manhole with water before the pumps were stopped. The frost had penetrated the wet, sandy soil to a depth of thirty inches. By frequent sharpening of the auger, it was possible to quickly drill these holes. Each manhole required 6 well points, and there were 13 manholes.

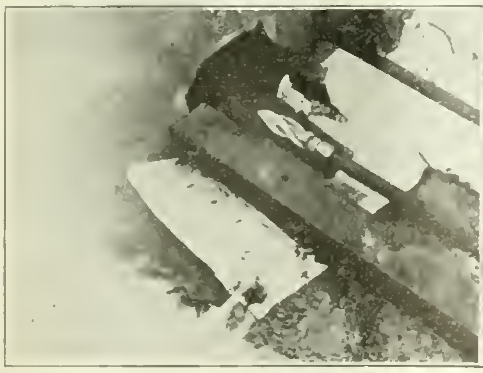
Fig. 3—Gimlet End of Pipe.

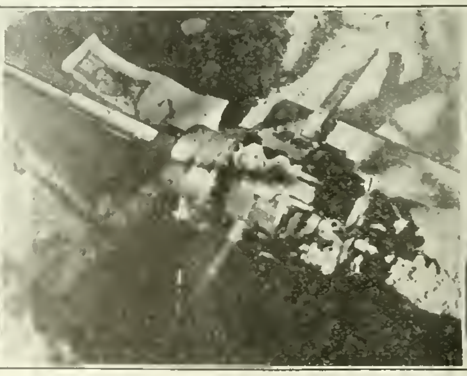
Fig. 4—Little Giant Air Drill Connected to Pipe.

Fig. 5—Gimlet Point.

Extending Gas Service Pipes Across a Heavily Travelled Boulevard Paved with Brick on Reinforced Concrete.—One section of this thorofare is lighted by gas street lamps. Where the posts were on the far side of the street, the pipes had to be extended by the use of a pipe jack. There were eight of these locations where repeated attempts had failed. A proposal was invited to lease the machine for cutting the pavement. A counter proposal was made to gimlet the pipes across. The answer to this was that the wooden cribbing on either side of the sewer prevented. After some urging, the gimlet trick was tried, and the eight pipes were quickly and accurately placed. At the point where the service was connected to the main, a hole was cut through the pavement with the hammer drill.

Extending 3 in. Iron Pipe Conduit Underneath a Railroad Track.—The following is quoted from the Electrical World & Engineer of Feb. 4, 1922, under the caption, "Conduit Forced Through Railroad Embankment by Air Drill":

"An air drill was put to rather novel use recently by the Commonwealth Edison Company in extending its underground plant beneath a railroad right-of-way. The railroad at the point is elevated about 18 feet above the normal grade and the embankment is 75 ft. wide. The company has a distributing pole line in the alley adjacent to the railroad, and desired to make a crossing but did not wish to employ overhead construction because of the height of pole necessary. After discussing various methods of making the crossing, it was suggested that 3-in. iron pipe be driven through the embankment, employing an air drill to rotate the pipe and using the rotation to force the pipe forward. An extra-heavy coupling for 3-in. wrought-iron pipe is 4.1 in. in outside diameter.

"A cone shaped pilot was constructed, the cone being 2 ft. long and 4.5 in. in base diameter and terminating in a cylinder 3 in. long. The cone was hollow and served partly as a lubricant reservoir, six holes being pierced through the shell to allow the lubricant to ooze out. This action was aided by a piece of steel tubing containing a piston and a spring, the spring forcing the cone were six pitched flanges, arranged from left to right, the flanges would act to drive it forward through the earth. For about 30 ft. it was possible to feed the pipe into the embankment in this way. At that point progress became so difficult that more positive feeding was necessary. Consequently a sleeve with a threaded interior was anchored to two anchors so that its axis coincided with the axis of the pipe. A hollow jack-screw 6 ft. 6 in. long was passed over the pipe and through this sleeve. In front of the jack-screw and fastened to it was a split pipe clamp. The jack-screw was then turned by the air drill, forcing the pipe forward."

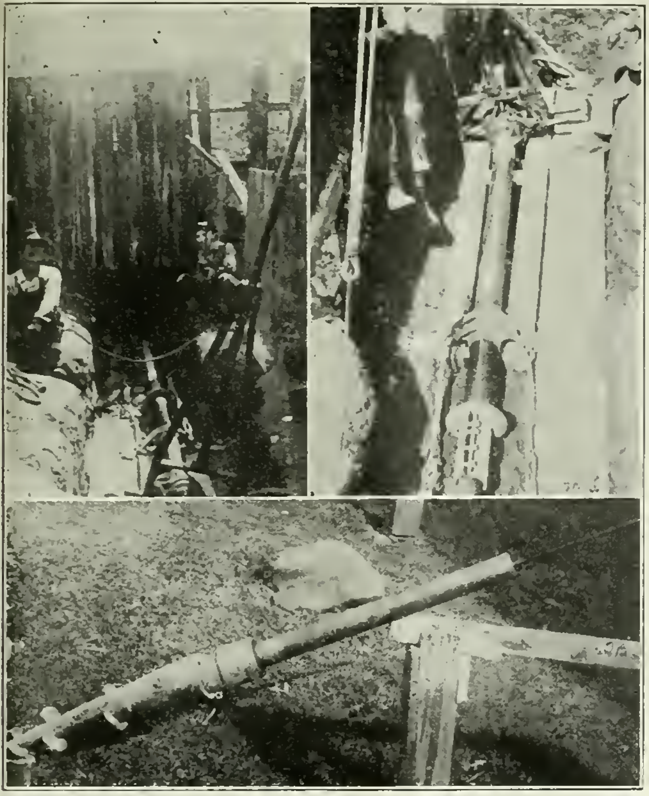

Fig. 6—Pipe. Fig. 7—Little Giant Air Drill and Pipe. Fig. 8—Flanged End of Pipe.

"When 6 ft. of the jackscrew was turned through, the clamp was loosened, the air drill reversed, the clamp pulled back 6 ft., again tightened on the pipe and again forced forward. It was then necessary to use a short piece of pipe as a spacer until the permanent pipe was far enough forward to insert another standard length. After the pilot was in 45 ft. it turned with difficulty. A resident of the vicinity told the foreman that the pilot had struck the slag ballast that was under the track before elevation. It took eight hours to go forward 12 ft. Then it began to rotate more easily, and in another six hours 75 ft. of pipe was in. An excavation was made and the pilot uncovered. It was found to be only 4 in. off the desired line. The second pipe was installed in the same fashion except that the pilot arrived on the other side 18 in. out of line. The total time for the two pipes was eight days. It seems probable with the experience gained that the performance could be repeated in four days.

"The total cost of the equipment and crew for eight days was $335. This does not include the cost of the pipe. The cost of trenching over the embankment was difficult to estimate in detail because the fill included large rocks. In addition, because of the continual passage of trains during the day, it would have required night work with a railway force on hand to place any bridging required. It was felt that $500.00 would be the minimum cost for this method."

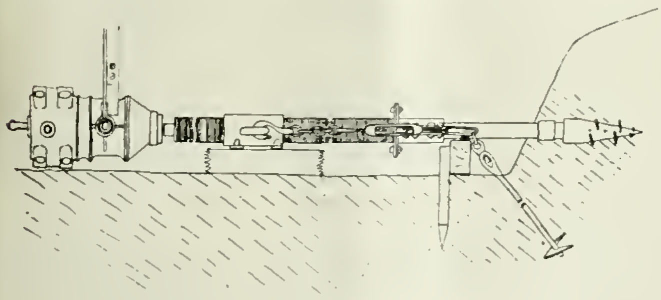

Fig. 9—Little Giant Air Drill, Pipe and Flanged End of Pipe.

Extending Pipes from Subway to Building.—A very interesting example of this character of work is illustrated in Fig. 10. An electric power utility was establishing a sub-station in one of the deep basements of a large, 11-story building owned by another utility. Fig. 11 shows the proposed work, as finally completed.

The plan called for two subway manholes, each to have two 4-in pipes and one 3-inch pipe extending downward and entering the basement through an opening 27 ft. below the alley level.

The two openings were cut, using two air hammers, one heavy one for drilling the holes and one lighter one for trimming.

After the openings were cut, clay was mined from beyond the wall to make an opening about 4 feet from the wall. The purpose of this opening was to set the bends and make up the couplings. The pipes were then screwed down (Fig. 10), with a rotary drill, using the same pilot that was employed for going under the railroad track (see above).

The three pipes were then terminated with 4-ft. radius bends, the screw couplings being made up by turning the pipe above ground with the air drill. The bends were then placed in the proper position and fastened. A fourth pipe was then driven down to the cavity. This pipe was used as a conduit for placing the concrete which was used to close and seal the openings and fill the cavity.

While this work was going on, another crew were setting up the structural iron work for the switches and installing transformers on the floor below. This involved a considerable amount of concrete cutting, for which the use of air tools was requested. This work was done in the intervals between other operations, and required about four hours' use of the tools, saving a much larger amount of hand labor.

Enough examples of these special jobs have been cited to illustrate the versatility of mobile equipment of this design.

In addition to those examples cited, the demonstrating machine has cut some pavement in zero weather. It has drilled a short section of ledge rock for placing subway. It has made three excavations 3 ft. x 8 ft. x 8 ft. for large platform anchors, and has drilled a large number of sockets in the concrete walls of manholes for placing cable racks.

With the increase in number of underground structures of public utilities and modifications of design to make them more substantial and permanent, it is felt that there will be a steadily increasing use for air tools in work of this character.

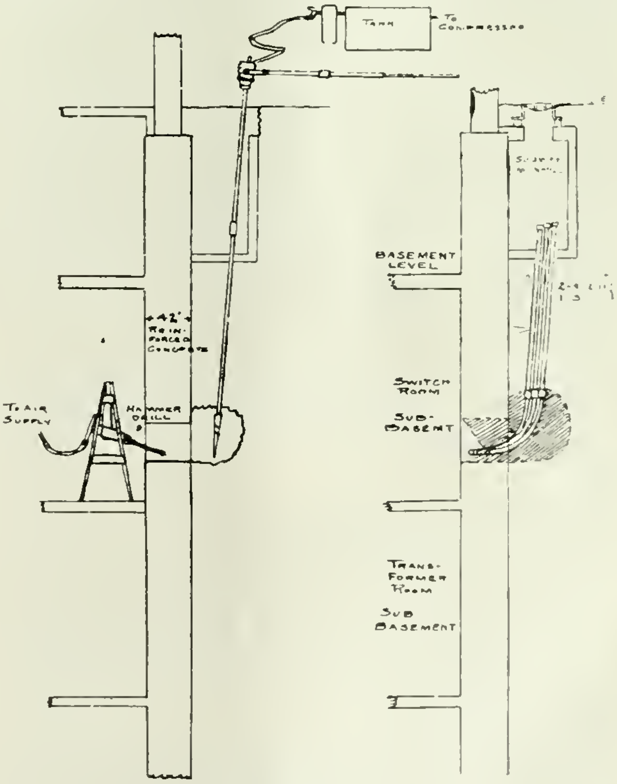

Fig. 10—Method of Extending Pipes From Subway to Building With Little Giant Air Drill and BQ-46 Hammer Drill.
Fig. 11—Work as Finally Completed.

Solution of Corrosion and Coagulation Problems at Baltimore

Water which is corrosive to iron pipes is found in the supplies of many cities. Many supplies originally not corrosive to an objectionable extent have been made so by chemical treatment, especially where alum is used as a coagulant. The most corrosive water is usually one whose hardness is below 100 p.p.m., and in some instances when it is very low it is necessary to use an alkali to reduce corrosion. How these corrosion and coagulation problems were solved at the Montebello filters of Baltimore, Md., was described in the May Journal of the American Waterworks Association by Mr. John R. Baylis, principal sanitary chemist of the filters.

Efforts are being made at Baltimore to reduce the corrosion to a point where there are no complaints. The supply is obtained from the Gunpowder river and is filtered at Montebello filters. Alum is used as a coagulant and lime is applied after filtration, unless occasionally a small amount is needed to produce a pH value sufficient for good coagulation.

The alkalinity of the water before treatment averages about 37 p.p.m., with a minimum of about 20 when the water is very turbid. The total hardness is about 42 p.p m., and the free carbonic acid averages 5 p.p.m. The average amount of alum used is 1.2 grains per gallon, and, when applied at the average rate, reduces the alkalinity 8 to 10 p.p.m. and increases the free carbonic acid 5 to 10 p.p.m. The maximum application of alum is about 3.5 g.p.g. for very turbid water, which reduces the alkalinity about 27 p.p.m, and increases the free carbonic acid above 20 p.p.m

The pH value before treatment averages 7 and is reduced to between 6 and 6.5 when the average amount of alum is added, and below 5 when the maximum amount is used. The terms increase and decrease in pH apply to the figures, which are the logs of the reciprocal of the hydrogen-ion concentration. Five is below the value necessary to obtain good coagulation, so at such times an alkali is applied near the same point as the alum.

Alum Used as a Coagulant.—Since the filter plant was put in operation in 1915 and until 1918, iron and lime were used exclusively as coagulants, but since the latter period alum has been used part of the time in 1918, most of the time in 1919, and now all of the time. When iron and lime were used, good coagulation was hard to obtain unless the amount of lime used was high, so it was applied most of the time in quantities sufficient to give after filtration a monocarbonate alkalininity above 10 p.p.m. and a pH value from 9 to 9.5. This procedure resulted in encrusting the sand grains in the filter beds, greatly increasing their size, and encrusting slightly the pipes in the distribution system. Except for hot water pipes the corrosion was slight, although a heavy dose of chlorine increased it somewhat. Complaints of "red water" during this time were few and were confined almost entirely to hot water pipes.

Difficulty in obtaining satisfactory results when iron and lime were used, due partly to the character of the water and partly to insufficient time in the mixing basin, brought about a change to alum. This change resulted also in a lower cost for coagulant, as the alum was more effective and could be used in much smaller quantities, the ratio being about two to one.

When it was first used the incrustation on the sand grains in the filter beds, consisting mostly of carbonate of lime, reduced the free carbonic acid to about 1 p.p.m. There was very little increase in corrosion for some time, but by the latter part of 1919 most of the incrustation had dissolved from the sand grains and the free carbonic acid increased above that in the raw water. There was an increase in the iron contents of the water passing through the distribution system, and soon complaints from "red water" became very frequent.

Corrosion Reduced by Lime.—Since October, 1919, lime to reduce corrosion has been used almost continuously. This method brought about other difficulties. Alum reacts best with a bicarbonate alkalinity. The application of lime, therefore, at approximately the same time as the alum greatly increased the amount of alum necessary to form good coagulation. Actual results compare fairly closely with experiments conducted at Jackson, Miss., in 1915 and 1916, on the effect of adding lime before alum. No provision was made in construction for the application of lime at any point other than at the entrance to the mixing basin. Recommendations advising the application of lime after the water has passed through the coagulating basins and just before filtration were made, but instead of applying at the point recommended it was applied at the end of the mixing basin just before the water passes to the coagulating basins. This was a great improvement over the other point of application, but it was still found impossible to add enough lime at this point to reduce corrosion to the desired point, without increasing the amount of alum. It was also found that coagulation perfectly formed is partly redissolved by the addition of lime in small quantities. When the water was very turbid, requiring the use of from 2 to 3 g.p.g. alum, lime greatly affected the coagulation, if enough was added to reduce the free carbonic acid to nearly the neutral point. Consequently at times of high turbidity the lime was not increased in the same proportion as the alum, so the water was frequently very corrosive and caused complaints.

Effect of Lime on Aluminum Hydroxide.—In Table I are shown the results of a few tests made to determine the amount of aluminum hydroxide dissolved by the application of lime at the outlet of the mixing basin, which is after the floc has been formed. Samples of filtered water from the two filter galleries were filtered through No. 40 Whatman's filter paper, one or two liters evaporated to dryness, and the iron and aluminum oxide determined gravimetrically. No attempt was made to determine the iron oxide, but it averaged only about 0.2 p.p.m. in the combined filtered water and if most of it came from the north gallery it would not affect the results materially. One grain per gallon of alum gives about 2.6 p.p.m. aluminum oxide (Al_2O_3), so these tests indicate that there is more aluminum oxide in the water from the north gallery, which is water that receives most of the lime, than was being applied. This is possibly due to aluminum compounds naturally in the water. Gravimetric determinations of the aluminum oxide in the composite monthly samples for August and September, after being filtered through alundum crucibles, average 1.5 p.p.m. The alumina in the filtered water is partly that naturally in the water and partly dissolved from the aluminum hydroxide. Lime was applied where it received only a partial mix in going to No. 1 settling basin, so some of the aluminum hydroxide was in contact with highly caustic water for a short time. It is safe to say that one-half of the floc in this basin was dissolved at times by application of lime at the outlet of the mixing basin.

Hydrogen-ion Concentration an Indication of Corrosive Qualities of Water.—The hydrogen-ion concentration determination seem to offer a better indication of the corrosive qualities of water than other current tests. For some time, therefore, we have been trying to find a concentration that will be most suitable for the water supplied to Baltimore city. A hardness of 50 p.p.m., which is about the average of that supplied to the city, requires a pH value of about 8, in order to reduce corrosion in cold water pipes to a point where there will be practically no complaints. Realizing that complaints are made only when corrosion is fairly rapid, a pH value of from 8.5 to 9 has been tentatively set as that desired. The indications are that 8.5 is sufficient. Harder water may have a pH value lower than this, and for very hard water it may be about 7 without danger of excessive corrosion.

In the attempt to keep the water near the desired pH value, it was soon realized that some other point of application of the lime was necessary. Experiments on dissolving aluminum hydroxided with an alkali clearly indicated that the proper point of application was after filtration, and not before, as formerly recommended. Changes have been made in the lime pipe lines so as to apply it at this point. Evidence to date in handling a very variable character of water clearly indicates that this is the proper point to apply an alkali to reduce corrosion when alum is used as a coagulant. It is necessary to use some alkali to create proper coagulation, if the pH value goes below a certain point, which has been found to be about 5.5 for the water here under discussion. Almost complete precipitation is obtained when the pH is between 6 and 7, and fairly good when between 5.5 and 6, so no lime is applied at the entrance to the mixing basin unless the pH value goes below 5.5 after the application of alum, and then only enough to bring it to approximately this value. A greater amount causes an increase in the amount of alum necessary. We have no data on precipitation for values above 7, except experimental, as our raw water never goes above 7.4. When alum is applied in minimum amounts (0.4 grain per gallon) it reduces the pH to about 7. Added alkalinity, if bicarbonate, indicates that good precipitation can be obtained when the pH is considerably above 7.

Importance of pH Values in Coagulation.—Recent observations on the causes of turbid water passing the filters, and their correction are typical of conditions that have happened a number of times since alum has been used as a coagulant. These will give some indication of the importance of pH values in coagulation.

Feb. 6, 1922. Raw water: turbidity 230, alkalinity 23, free carbonic acid 5 and pH 6.8; 2.5 grains per gallon alum applied, and after passing through mixing basin with about one-half hour mix contained: alkalinity 8, free carbonic acid 26.0 and pH 5.1. Coagulation was imperfect and turbidity after filtration was 5. Samples collected from outlet of mixing basin settled fairly rapid to a turbidity of about 10, then no appreciable change in seven hours. After settling over night the pH changed to 5.7, coagulated during the night and sedimentation was complete the next morning. As soon as the pH was found to be low the alum was reduced to 2 grains per gallon resulting in some improvement. The application of a small amount of lime to increase the pH to 5.6 helped considerably and results were very good but not perfect. Due to the turbidity and the effect of lime on the amount of alum necessary for coagulation, 2 grains per gallon was not enough and samples settling over night did not show perfect, nor any improvement after standing forty-eight hours, when they were discarded. A sample treated in the laboratory with 2 grains per gallon alum and stirred thirty minutes showed very good floc and settled rapidly to a turbidity of 8 in two hours, pH 5.4. No change in seven hours, but standing over night pH changed to 5.6, coagulation perfect and sedimentation complete. Laboratory sample treated with 1.5 grains per gallon alum and stirred thirty minutes showed perfect coagulation and complete sedimentation in two hours. The alum applied in the plant was reduced to 1.5 grains per gallon and the addition of lime with the alum stopped. Water thus treated showed good coagulation and filtered perfectly.

Feb. 11, 1922. Raw water: turbidity 120, alkalinity 22, free carbonic acid 5 and pH 6.9; 1.82 grain per gallon alum produced very poor results, filter effluent having a turbidity of 4. Samples of effluent from the mixing basin showed: alkalinity 7, free carbonic acid 38.3 (very high but checked by several samples), pH 5.2. Settled to turbidity of 8 in two hours and showed no further change in seven hours. Settling twenty-four hours pH changed to 6, coagulation became perfect and settled completely. Alum reduced to 1.34 grain per gallon which showed an alkalinity of 15 and pH 6.5. Coagulation complete and filtered perfectly. Laboratory sample treated with 1 grain per gallon alum and stirred twenty minutes produced a good floc that settled rapidly to turbidity of 3. No change in forty-eight hours showed that this amount of alum was insufficient for proper coagulation.

These, and other results not reported here, show that the pH value should not go below 5.5 for good coagulation, and demonstrate also the advantage of pH values over alkalinity in determining if an alkali is needed with the alum. During only a very small per cent of the time at Baltimore is the pH reduced below 5.5 after the application of alum, but there are a number of cities treating water for filtration where the pH is reduced below this figure for a large percent of the time. Large plants with close supervision can adjust their waters to any desired hydrogen-ion concentration, but small plants with no chemist in charge may have some difficulty in producing good results. Possibly the best plan is to do as the author did a few years ago at Jackson, Miss. The settling basins were used in series and the lime was applied at the point where the water passed from one to the other. Most of the floc settled in the first basin, but frequently the water had a milky look before the lime was applied. At such times the water coagulated again in the second basin when lime was used. With our present knowledge of hydrogen-ions best results may possibly be obtained at this plant by applying a small amount of lime at approximately the same point as the alum to produce a pH of about 5.5 and applying the balance after filtration to prevent corrosion.

Use of Lime to Prevent Corrosion.—Many cities desire to prevent corrosion, yet it is surprising how few make any conscious attempt to do so. If iron and lime are used as coagulants it is necessary to have a high pH value (8.5 to 9.5) to produce good coagulation, so where these chemicals are used there are few complaints of corrosion. Iron is not suitable for all kinds of water, especially when highly colored, so alum will continue probably to be a most widely used coagulant. When used with soft water it will cause considerable corrosion of the service pipes, which can, and should be, reduced in many instances. The difficulties heretofore experienced in trying to use an alkali with alum has delayed its application in many instances, but with our present knowledge of coagulation processes it should become more extensively applied.

Considerable study has been given to the degree of corrosion causing complaints and its prevention. Extensive experiments were conducted to determine the total corrosive qualities of the Baltimore water supply, but not much of practical value was learned. It was shown that all the waters used attack pure iron with a bright surface very rapidly. Water with a pH of 5 attacked the entire surface, whereas that with a value of 9 corroded only in spots. The dissolved oxygen determines the total corrosion possible. If this were all used up in the Baltimore supply the life of iron pipes would be very short, possibly less than two years for wrought iron service pipes. The total corrosion possible is about 300 lbs. of iron for each million gallons of water, or about 10,000,000 lbs. yearly. With a bright surface exposed in 1½-in. wrought iron pipe, the iron contents of the water was increased about 15 p.p.m. in 30 minutes. This result shows the experiments on iron having a bright surface exposed are practically worthless. It is the rate of corrosion in service pipes, with partially protective coating, that concerns the waterworks official. The protective coating may be one applied by the manufacturer or it may be formed

TABLE 1.—SHOWING SOLUBLE IRON AND ALUMINUM OXIDE IN FILTERED WATER. ALL SAMPLES FILTERED THROUGH NO. 40 WHATMAN FITER PAPER: GRAVIMETRIC DETERMINATIONS OF Al_2O_3 AND Fe_2O_3.

Date. 1921.	Turbidity.	Grains per gallon alum.	Alkalinity. Mixing basin.	Alkalinity. North gallery.	Alkalinity. South gallery.	Free carbonic acid Mixing basin.	Free carbonic acid North gallery.	Free carbonic acid South gallery.	Monocarbonate alkalinity Mixing basin.	Monocarbonate alkalinity North gallery.	Monocarbonate alkalinity South gallery.	pH Mixing basin.	pH North gallery.	pH South gallery.	Iron and aluminum oxide P. P. M. Al_2O_3 and Fe_2O_3 North gallery.	Iron and aluminum oxide P. P. M. Al_2O_3 and Fe_2O_3 South gallery.	Iron and aluminum oxide P. P. M. Al_2O_3 and Fe_2O_3 Mixing basin.
August 19	60	1.25	..	..	..	....	...	...	...	...	...	...	8.4	7.9	6.0	2.5	...
August 22	88	1.25	..	47	40	....	1.8	4.0	0.0	0.0	0.0	...	7.8	7.2	4.1	1.7	...
August 29	25	0.67	..	56	51	....	0.0	1.3	...	6.0	0.0	...	8.5	7.8	3.4	1.5	...
August 30	23	0.60	..	54	51	....	0.0	1.7	...	4.0	0.0	...	8.4	7.7	3.0	2.2	...
August 31	23	0.60	..	56	51	....	0.0	1.7	...	3.0	0.0	...	8.5	7.6	5.0	2.8	...
September 1	23	0.55	..	53	48	....	0.0	3.1	...	2.0	0.0	...	8.4	7.5	3.4	1.4	...
September 2	20	0.55	..	55	49	....	0.0	4.4	...	1.0	0.0	...	8.4	7.3	4.6	1.0	...
September 16	140	1.82	19	34	28	20.7	4.8	9.7	0.0	0.0	0.0	6.0—	7.1	6.7	2.2	1.4	3.2
September 19	70	1.66	15	39	30	28.6	3.1	8.0	0 0	0.0	0.0	6.0—	7.5	6.7	2.4	1.6	1.0
September 30	60	0.64	37	49	45	10.6	6.0	4.0	0.0	3.0	0.0	6.7	8.4	7.4	3.7	1.6	1.2
Average	53	0.96	24	49	44	20.0	1.1	4.2	0.0	2.1	0.0	6.2—	8.1	7.4	3.8	1.8	1.8

Note—Lime is added to water at outlet of mixing basin, and does not mix thoroughly before it divides to go to the two settling basins. Consequently more lime goes to No. 1 settling basin than to No. 2. The effluent of the two basins are connected, but most of the water supplied the filters in the north gallery comes from basin No. 1, and the south gallery from basin No. 2. Mixing basin samples are before lime is added. Fe_2O_3 averages about 0.2 p.p.m. One litre samples from 8-19 to 9-2; two litre samples from 9-16 to 9-30.

by the water passing through. Artificially applied coatings eventually wear off or dissolve from the pipes and protection then depends on the coating naturally formed.

Rate of Corrosion at Baltimore.—To form some idea of the rate of corrosion taking place in the water pipes of Baltimore, daily tests have been made of the iron contents of the water leaving the filter plant and of that in the laboratory tap, which is water that has passed through several miles of cast iron mains. This sample gives possibly a fair idea of the total time of travel in the mains. The difference in iron between the two samples is a fair average of that going into solution or in suspension. How much remains as scale we are unable to tell, but it is possibly less than half of the above amount.

COMPARISON OF IRON, CARBONIC ACID AND DISSOLVED OXYGEN IN FILTERED WATER, P.P.M.

	Iron (Fe)			Free CO_2	
Year.	Filtered.	Laboratory tap.	Increase in iron.	filtered water.	Dissolved oxygen.
1919	0.07	0.15	0.07	4.0	7.8
1920	0.10	0 21	0.11	6.6	7.8
1921	0.14	0.25	0.11	5.0	7.2

A study of the records indicates that, had no lime been applied, the iron contents would have been increased about 0.30 p.p.m. in passing through the cast iron mains. A large portion of the water passes through the wrought iron service pipes, which are more readily attacked, so that the actual increase in iron is greater than the laboratory sample shows. The total corrosion, including the scale adhering to the pipes, is estimated at 0.60 p.p.m. when lime is not used. The amount of water passing through the distribution system has averaged about 100,000,000 gal. daily for the past four years, so the total corrosion would be about 500 lbs. daily if no lime were used. Leaks, damages to pavements and buildings, and cost of repairs, amount to a great deal per pound of pipe replaced. It may amount to as much as 50 cents per pound in some cities.

Saving by Use of Lime.—The use of 0.39 grain per gallon of lime, costing about $25 per day in 1921, reduced the corrosion to a total of approximately 0.22 p.p.m. The application of the lime after filtration as is now being done, to give a pH between 8.5 and 9, requires about 0.55 grain per gallon, costing about $35 per day. The total corrosion is reduced to at least 0.10 p.p.m., showing that the saving in piping is worth considerably more than the cost of lime used. Besides this procedure produces more palatable water. It has the disadvantage of making the water harder, requiring the use of more soap. Whipple, in "The Value of Pure Water," estimates that each person completely softens one gallon of water daily. Assuming that we have progressed somewhat in cleanliness, it is safe to estimate that 1,000,000 gal. is softened in Baltimore daily. The increase in soap hardness is about 10 p.p.m., which increases the amount of soap used about 2,000 lbs. per day, basing the estimate on laundry soap. The increase in cost of soap and the cost of lime may be somewhat greater than the value of the iron saved, but satisfaction has a value that will more than offset this difference, if there is any. If there were no depreciation in the pipes, water departments would be justified in preventing "red water." In Baltimore the total added cost for lime, soap, etc., amounts to only about 15 ct. per year for each inhabitant. Comparing this with the amount we spend for satisfaction in food and clothes, it amounts to practically nothing.

The increase in iron contents of the water passing through the pipe is now kept at about 0.05 p.p.m, and represents a total corrosion of not over 0.10 p.p.m. for the amount consumed. Complaints from "red water" have ceased almost entirely. The ideal point is possibly where the tendency to encrust and corrode are at a minimum. Since we have found the pH value of this point to be about 8.5 for the water supplied to Baltimore, we have no difficulty in keeping corrosion reduced to a low rate.

Method of Making pH Determinations at Montebello.—Color standards are used in making the pH determinations. These standards are prepared according to the method recommended by Clark and Lubs, and sealed in 15x100 mm. pyrex tubes. These tubes are thoroughly cleaned, drawn at the top, filled with 10 cc. of the standard, and sealed. Standards are made for each 0.2 pH variation from 5.2 to 9.6. Brom-cresol purple (5.2-6.6), bromthymol blue (6.2-7.4), phenol red (7.0-8.4) and thymol blue (8.2-9.6) are the indicators used. Solutions are made the strength recommended and 0.5-cc. quantities are used both in the standards and the samples.

Sample bottles are thoroughly rinsed with water the same as the sample, then the sample collected and tested immediately. A tube the same size as the standard is thoroughly rinsed with the sample. A thoroughly cleaned 10-cc. pipette is filled with the sample, discarded, and another 10-cc. portion withdrawn and put in the tube. Five-tenths cubic centimeters of the indicator is added to the tube, mixed and a comparison made. Results are recorded to the nearest 0.1 pH value.

For clear solutions, or when slightly turbid, comparisons are made by holding the tubes against a white piece of paper. For accurate results a comparator block should be used if the turbidity is over 20, though fairly accurate results can be obtained with turbidities as high as 100.

The standards are kept in a dark room, except for a few minutes when in use. They are checked every two months, and if any show variations, they are replaced.

Uniform Policy on Degree of Treatment of Sewage Discharge Into Delaware River

During the past few months inspections of the Delaware River which forms the boundary between the states of Pennsylvania and New Jersey, have been made and conferences held between the engineers of the departments of health of the two states. As a result a uniform policy as to degree of treatment of sewage discharged into the Delaware River was agreed upon and has been approved by the commissioners of health of the two states. The policy follows.

Sewage discharged into the Delaware River from the northern limits of the states of Pennsylvania and New Jersey to a line above the city of Easton and the town of Phillipsburg shall be treated to such an extent as to produce a clarified and oxidized effluent; and also, that so far as legally possible, the state department of health will prevent the discharge of untreated industrial wastes into this portion of the river.

Sewage discharged into the Delaware River from a line above the city of Easton and the town of Phillipsburg to a line above the borough of Morrisville and the city of Trenton shall be treated to such an extent as to effect the removal of settleable matter by means of efficient sedimentation; provided, however, that in cases where such settled sewage may be discharged into this portion of the river that it may prejudicially affect a water supply, the effluent shall be further treated to adequately safeguard the purified water supply obtained from the river; and further provided, that when plans for sewage treatment works are approved, where the sedimentation of sewage is the only treatment required under this policy, the approval shall be subject to the condition that means for the further purification of the tank effluent shall be installed when deemed necessary by the state department of health; and also, that so far as legally possible, the state department of health will restrict the discharge of untreated industrial wastes which might be a menace to public health or create a nuisance to either sight or smell.

Sewage discharged into the tidal portion of the Delaware River, from and including Morrisville and Trenton and to and including Philadelphia and Camden, shall be treated by means of sedimentation and the effluent discharged through submerged outlets into deep water in the Delaware River; provided, however, that in cases where such settled sewage is or would be discharged into the said tidal portion of the Delaware River at such a distance above or below a water works' intake that it may prejudicially affect such water supply, the effluent shall be further treated to adequately safeguard the purified water supply obtained from the river; and further provided, that when plans for sewage treatment works are approved, where sedimentation of sewage is the only treatment required under this policy, the approval shall be subject to the condition that means for the further purification of the tank effluent shall be installed when deemed necessary by the state department of health.

From data now available it is considered that the discharge of only settled sewage into the aforesaid tidal portion of the Delaware River within two miles of a waterworks' intake of an efficient filtration plant may prejudicially affect such water supply.

In case the said point of sewage discharge is from one state and the said waterworks' intake is in the other state, so that the sewage effluent while discharged within the aforesaid two miles would have to cross the river to reach the water intake, then before a decision is reached by the state department of health having jurisdiction over the discharge of sewage, the case shall be taken up with the other state department of health for a careful determination of the probability of the discharge of only settled sewage prejudicially affecting the water supply.

Hydraulic Equipment and Power House Design

Factors Affecting Installation of Main Units and Auxiliary Equipment, Outlined in Paper Presented at Water Power Symposium at University of Toronto

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Where the type of turbine for any given development has been fixed the next consideration in power house design is the number of units to be installed. As a general rule they should be made as large as possible so that their number may be kept to a minimum on account of simplification of operation and lower initial cost.

There are always other features however which may modify this general consideration. For example, in an isolated plant (i. e. one not connected with other plants) the number of units should be not less than three, and in many cases four, so that sufficient flexibility of operation may be obtained and also because a failure in any one machine will not tie up too great a proportion of the plant.

Another feature that usually affects the number of units is the fact that only a portion of the plant is installed initially, on account of the load requirements being smaller than the ultimate capacity.

Method of Procedure for Large Installations.—In a large installation where the above considerations do not apply to any great extent the following example indicates the method of procedure in the determination of the size and speed of the individual units.

Assume a development of 60,000 H. P. at 50 ft. head. First assume an installation of five units of 12,000 H. P. each. An examination of performances of modern turbines shows a generally average ratio existing between specific speed and head, as follows:

Head.	Specific speed.	Head.	Specific speed.
20	100	300	33
50	75	500	27
100	52	600	24
200	39		

The fundamental expression for specific speed is $K = R.\,P.\,M.\,(H.\,P.)^{1/2}/H^{5/4}$, where K is the specific speed, R. P. M. the revolutions per minute of the turbine, H. P. the horsepower developed, and H the operating head.

From the above tabulation it will be noted that a specific speed in the neighborhood of 75 is correct for the unit under consideration.

Hence, $R.\,P.\,M. = 75\,(50)^{5/4}/(12{,}000)^{1/2} = 91$.

If the frequency of the plant is 60 cycles per second the nearest sychronous speed to this is 90 r. p. m. which would satisfactorily meet the conditions. It would require an 80 pole generator, however, and it would probably work out more economical to reduce the units to 10,000 h. p. each. This would require six machines operating at 100 r. p. m.

For high heads with relatively small output this analysis will indicate speeds in excess of the best practice. For example it would show a speed of 820 r. p. m. for a 6,000 H. P. unit under 600 ft. head. Such a speed is almost sure to give trouble after a short period of operation as the slightest unbalance will set up dangerous vibrations which become aggravated as time goes on with the result that the units require frequent overhauling with consequent loss of time in service. Generally it is not advisable to operate turbines of capacities in excess of 1,000 H. P. at a higher speed than 500 r. p. m.

The Auxiliary Equipment.—The auxiliary equipment in any plant plays a most important part in its output from the point of view of regulation and of that ideal of all operators—continuity of service. It must be installed with two vital objects in mind; ease and convenience of operation, and absolute dependability under all emergencies. This latter condition can be attained in many cases only by duplication of the apparatus.

Under the classification of hydraulic auxiliary apparatus is included:

1. Service units.
2. Governor pressure system.
3. Penstock valves.
4. Lubricating system.
5. Service water supply.
6. Drainage.

The governors are not included as they are essentially part of the turbines.

The service units must be in duplicate since they are the source of power for the plant equipment such as emergency excitation for the main units, the governor pressure pumps, the lighting system, flood drainage pumps, traveling cranes and repair shop machinery.

A major interruption may shut down the whole plant and in order to get back on the load without delay, service from the governors and exciters must be immediately available. For this reason one service unit at least should be independently turbine driven. The layout requires as much care and attention as that of the main units and it is an unfortunate fact that auxiliary equipment is frequently installed in a manner which indicates a lack of appreciation of its vital function. The unit should be completely independent in that its own governor pressure system should be separate from the main system with provision for interconnecting with it.

Systems for Supplying Pressure Fluid for Governor Operation.—For supplying pressure fluid for governor operation two systems are available and as both give satisfactory results it is a difficult problem to determine which to install in any given development. The first, or multiple unit system, consists in having a separate pump and sump tank for each unit, and the second, or central system, in having the units connected through headers to a central pump.

For security of operation the multiple system is tied together with a header on the pressure side provided with sectionalising values so that in the event of failure of any pump, the governor for the unit can be connected to the header and supplied by the other pumps in the system. To provide against failure in the central system a duplicate pump is installed which can be thrown into service should the first pump fail. A duplicate system of headers is also frequently advisable.

The Multiple Unit System.—The advantages of the multiple unit system are, first its greater flexibility, and its simple application to an initial partial plant installation. As the plant grows individual pump units can be added as the turbines are installed, and in this way the system is always complete in itself. Another advantage is that the failure of one pump unit does not in any way cripple the service, since with all the units being tied together the remaining pumps in the system will easily take care of the disabled unit. The main disadvantage of a multiple unit system is found in the fact that a great proportion of the operating attention is required for the maintenance in service of a number of small units. Multiplicity of pumps means more failures of small parts with a consequent danger of an insignificant failure being responsible for the shut-down of a main power unit.

The Central System.—The advantage of a central pumping system lies in the simplicity of the lay-out, with few parts to give trouble and with concentrated operating attention. Furthermore, since the operating fluid for the whole plant is handled by one pump, this pump is necessarily of large capacity, resulting in a rational design and one of much better operating characteristics. The pump in the central system is therefore usually of the multiple stage, centrifugal type, which is ideal for the varying load conditions imposed by governor service. In the multiple unit system the pump capacities are not large enough to permit satisfactory centrifugal designs, with the result that they are usually of the gear or plunger type, and consequently noisy in operation.

The main disadvantage of a central system lies in the fact that for partial plant installation the layout is unbalanced and of too great capacity for the few number of units initially installed. If the pump is automatic, electrically controlled and small output demanded results in frequent starting and stopping with consequent wear and tear on the motor; or if operated continuously through pressure regulating devices the governor fluid becomes very hot.

With the use of centrifugal pumps it has been found the oil as a pressure medium is not satisfactory, owing to the emulsification due to the churning action of the pump. For this reason water treated with 1 or 2 per cent of a soluble oil or a small amount of bichromate of potassium is now used and is found to operate successfully. Water thus treated acts efficiently as a lubricant in the working parts of the governor and has no tendency to produce rust.

There is a tendency in the present pressure systems to design the operating cylinders on the turbines to work at lower pressure than formerly; where in the older plants this pressure was from 200 to 250 lb. it now ranges in the modern developments from 135 to 200 lb. This results in much less trouble from wearing of the valve seats and leakage in pipe connections.

In the older type smaller capacity turbines the emergency control in the event of governor failure could always be had by throwing the turbine gate mechanism directly over onto hand control. As the capacities increased this direct hand control became too cumbrous and difficult to operate owing to the large masses in the gate mechanism which had to be moved. Hand control was then obtained by simply switching over from governor control to hand control of the pressure operating the governor cylinders. Such an arrangement however still left the control of the unit dependent on the maintenance of the governor pressure system, and if this failed control of the unit was practically impossible. In plants where the head is 200 ft. or more it is therefore advisable to connect the governor pressure system direct to the penstocks, thus permitting penstock pressure to operate the governor in extreme emergency. Where the head is lower than 200 ft. and in consequence not sufficient to operate the regulating cylinders the only recourse left is to install hand pumps directly on the regulating cylinders. With such an arrangement the machine can be shut down, but it necessarily takes a considerable length of time.

The Cement Gun in Waterworks Practice

During the past 8 or 10 years the cement gun has been used in the construction or repair of a large number of reservoirs. Some of the instances of its application were given by Mr. L. R. Talbot in a paper presented before the Iowa Section of the American Waterworks Association. The notes following are taken from the paper.

The gun is adaptable for building new reservoirs which are above ground, as well as lining the excavated type. In 1914 a reservoir was built at Elmhurst, N. Y., without the use of forms of any kind. The reinforcing was erected and a light frame used as a backing until enough material had been deposited to support itself, when the frame was moved ahead. A better scheme than this was used at Ford-City, Penn., in 1920, where a circular reservoir 110 feet in diameter and 17 feet deep was constructed of "gunite." The only poured work was that for an annular footing slab under the wall. Vertical reinforcing consisted of 1 in. square rods and horizontal reinforcing was 1 in. twisted bars, spaced according to pressure requirements. Two layers of mesh reinforcings were used. The reinforcing was erected entirely and tied together, then a light wood form or backing was built on the outside and against the steel. Mesh was applied to the inside and the inside was "shot." The forms were then removed and another layer of mesh applied to the outside and the outside was shot, bringing the wall to the required thickness. The walls were 13 in. thick at the bottom and tapered to 5 in. at the top. The floor was about 4 in. thick and reinforced with mesh in both directions. It has been in use about a year now and is giving perfect satisfaction. The contract price was $15,000 complete, which was less than bids that were received by the city for a poured concrete tank of the same dimensions. Labor and material prices when the job was built were about at their peak, so that a similar tank could probably be built at the present time for much less money.

At Kansas City, the Turkey Creek reservoir was lined in 1920 and put in good shape and beyond the need of repairs for a long time to come.

Trouble in maintaining linings, at Council Bluffs due to ice conditions and general deterioration, was experienced. The walls were cleaned off and a coating of reinforced "gunite" was applied to solve the difficulty. In addition, the new reservoir had a light coat applied over the surface for water proofing purposes.

The reservoir at Mt. Vernon, Iowa, showed ground water seepage. The reservoir is underground, the bottom being 26 ft. below the surface. The seepage amounted to about 100,000 gallons in 24 hours when the reservoir was kept pumped down. When it was decided to remedy this condition, the reservoir was pumped down and about 20 weep pipes were put in to take care of the inflow, thus drying the walls. "Gunite" was applied in successive coats, until 5 in. had been placed over the area where the seepage was worst. Finally the pipes were capped and were covered with a knob of "gunite." No trouble has since been experienced.

One of the largest jobs done in 1921, amounting to about 250,000 sq. ft., was the lining of the walls of the reservoir at Nashville, Tenn. Some work was done at Nashville in 1914 which was successful. The last job consists of coating the entire surface walls with "gunite," then placing a coating of mastic, and finally a 3-in. coat of "gunite."

At Pittsburg, Pa., a few years ago, the Herron Hill reservoir, which is of 10,000,000 gal. capacity and the oldest in the city, was leaking at the rate of 1,000,000 gal. a day or 10 per cent. It was cleaned out, and a 2 in. "gunite" lining was applied, reinforced in both directions with American Steel and Wire triangular mesh. It was estimated that a saving of $70,000 was affected on this job by using "gunite" rather than a poured double slab, which was what they had originally intended to use. The lining was made continuous with no expansion joints. A solid panel fence was built around the reservoir and a watch house was built with the cement-gun. A test made after the completion of the work showed a loss of less than 10,000 gal. in 24 hours, with no correction for evaporation.

Much the same methods were used in lining the Lake Elizabeth reservoir on the North side of Pittsburgh.

In addition to the projects enumerated above, brief mention should be made of similar work carried out at Montreal, Quebec, on the Outremont Reservoir, at San Francisco, Cal., on the Twin Peaks Reservoir, at Elmira, N. Y., and at Great Falls, Mont. for the Anaconda Copper Co.

Cost of Water Purification at St. Louis

The following tabulation from the annual report of the Water Commissioner of St. Louis, Mo., for the year ending April 1, 1922, gives a comparison of the costs of the various parts of the purification work during the past five years, based on the quantity of water delivered to consumers:

COST PER MILLION GALLONS, BASED ON CONSUMPTION. 1917-1922.

	1917-1918.	1918-1919.	1919-1920.	1920-1921.	1921-1922.
Old Plant—					
Lime	$2.94	$3.72	$3.89	$5.30	$4.51
Iron	.57	.82	.67	.77	.97
Unloading	.09	.12	.12	.15	.11
Operating, maintenance and repairs	.41	.60	.59	.57	.70
Water, coal, oil, etc	.05	.08	.05	.06	.06
Light and power	.10	.12	.11	.13	.11
Chemical work	.34	.30	.31	.39	.38
Basin cleaning	.17	.22	.26	.25	.50
Basin repairing	.02	.02	.02	.01	.03
*Switching and demurrage	...	...	.22	.23	.27
* Total—Old plant	$4.09	$6.00	$6.24	$7.86	$7.64
Filters—					
Aluminum sulphate	$1.13	$1.37	$1.92	$1.78	$2.10
Chlorine	.27	.31	.29	.26	.37
Operating, maintenance and repairs	.77	.89	.94	1.10	1.14
Coal, miscellaneous supplies and expenses	.36	.39	.39	.42	.47
Light and power	.21	.24	.31	.35	.32
*Switching and demurrage	...	...	.02	.03	.04
Total	$7.43	$9.10	$10.11	$11.80	$12.08
Total consumption for year in million gals	38,090	36,840	38,094	38,161	37,782
Cost of Chemicals—					
Lime per ton average 2 contracts	$6.86	$8.75	$10.03	$12.664	$11.66
Sulphate of iron, per ton, average	12.84	16.84	18.48	15.303	15.20
Sulphate of alumina, per ton, average	22.25	27.60	30.49	30.036	29.06
Chlorine per pound	.13⅜	.12⅝	.09¼	.0805	.0916

*Switching and demurrage in years 1917 to 1918, inclusive, are included in operating, maintenance and repairs, etc.

Under the head of lime, iron, sulphate of alumina and chlorine are included all charges connected with the switching of these materials from the interchange tracks at Bissell's Point and Humboldt Ave. to the Chain of Rocks.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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E. & C. Index Furnished Only on Request

The index for Vol. LVII—January-June, 1922—issues of Engineering and Contracting will be ready for distribution shortly. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Shall Coal Mines Become Public Utilities?

The coal mine "capacity of output" of America is about double the normal coal consumption, and there are fully 30 per cent more coal miners than are needed to produce the coal normally required. It has been suggested that the government may somehow be able to remedy this uneconomic condition, possibly by regulating coal mining as it has regulated railway operation. Heaven forbid. It is just 16 years since Congress passed the Hepburn bill that gave the Interstate Commerce Commission the authority to regulate railway rates. The effect has been to starve the railways and thus to bring almost a cessation of railway development. Even before the world war began, our railways had reached a very bad financial condition, as a result of restrictive control by the Interstate Commerce Commission. So that the present plight of the railways cannot be attributed to the effect of the war.

Now it is being seriously proposed to place coal mines in the category of public utilities, and to regulate the price of coal and the conditions of employment. And when the successful precedent for such an experiment is demanded, the finger is pointed at the regulation of the railways by the Interstate Commerce Commission! This is akin to arguing in favor of socialism by pointing to Russia; for the railways of America are about as sorely in need of famine relief as are the peasants of the soviet.

If the government will keep hands off the regulation of coal prices, competition among the 10,000 coal mines will eventually weed out those that are the least economic producers, and with this elimination of the "unfit" will go elimination of most of the unnecessary miners who are struggling to remain on the pay roll whether they are needed or not.

Many students of railway economics are coming to the conclusion that a restoration of competitive conditions and freedom to name their own rates for freight and passenger traffic would soon cause a great revival of railway development. For example, railway electrification would certainly occur on a large percentage of railway mileage were investors reasonably sure that they would not be deprived of most of the resulting profits. As it now stands, who wants to invest in railway securities for the purpose of electrifying a railway? The history of railway rate regulation for 16 years has shown that almost as soon as net earnings increase, railway rates are reduced, so as to hold them below an average of 6 per cent on the investment. Even that scant percentage is not guaranteed.

Nearly all the incentive for economizing by the investment of capital in better equipment, lower grades, electrification, etc., has been destroyed by the decisions of the Interstate Commerce Commission—a singularly myopic commission, and one that has remained very shortsighted in spite of changes in its membership. With incentive for economy through additional investments destroyed many of our once famous transportation systems have grown rapidly decrepit and unprogressive.

Cities, like Chicago, have howled for railway electrification while their own howling and the soot from the locomotives have made them black in the face. But capital has waved a gay farewell to them, and has sailed to ports where an I. C. C. cannot say: "In our opinion 5¾ per cent is a fair return."

The Know-It-All "Representative Citizen"

Each day the "Inquiring Reporter" of the Chicago Tribune interviews five "representative citizens" on the street, asking them to answer some question, often of a political nature. We have been pretty steady readers of these answers, yet we do not recall a single instance in which such a "representative citizen" failed to answer a political question, on the ground that he or she had not given it sufficient study to warrant having an opinion. From the desirability of voting bonds for the rebuilding of an old bridge to the desirability of public ownership of the street railways, these "representative citizens" always know the answer and can give "reasons" for the belief that is in them. Typical of the usual five we read the opinions of "a sales lady" at Marshall Field's, a barber at the Sherman Hotel, a bank clerk at the First National Bank, a typist in the Railway Exchange Bldg., and a "young matron" from Evanston. Three of them tell us that prohibition is desirable, and why. Two of them tell us that prohibition is not desirable, and why. At another time, three explain why government ownership of railways should be brought about, while two explain the economic dangers of such a form of socialism.

It is all so spontaneous in expression—this omnipotent knowledge the "representative citizen" has absorbed from the daily papers—and so American.

What an indictment of our public schools and of our newspapers such a spectacle is. Consider the sort of graduate that these two educational institutions produce—a man or woman who thinks himself or herself competent to answer offhand any political economic question that may be asked! Were not the gravity of the matter so great, no farce could be funnier.

Quite evidently our schools are teaching boys and girls to have opinions, and they mistake the having of an opinion for the right to have an opinion. School teachers who themselves have never learned the methods of able thinkers are teaching our children "how to think." Newspaper editors scarcely more able than our teachers are illustrating the callowness of their school training every day—their editorials, for they express positive opinions on every conceivable topic. Today an editor knows nothing about a given economic question, but tomorrow morning he will bombast you an answer in the most approved editorial style.

Is not the besetting intellectual sin of this generation the belief that practice of uttering opinions on any subject without having previously studied the subject?

The Summer Session of Chicago's Class in Municipal Engineering

Our editorial of August 2 entitled "Chicago's Eighteen Municipal 'Experts' Go to Europe," was defective in its failure to mention the presence of a nineteenth member of the party, Mr. C. D. Hill, Engineer of the Chicago Board of Local Improvements. While regretting the error, we pass the buck to the newspaper which failed to give Mr. Hill's name in stating the party's personnel.

The omission was brought to our attention in a letter published below, and when recognized puts the matter in a very different light from that in which we first presented it. The eighteen councilmen, it now appears, are not experts as we at first understood, but merely student devotees at the shrine of learning, humbly and laboriously following a course of instruction administered by a man of knowledge. As a duty to their city and their constituents they are voluntarily undergoing the hardships of ocean travel and land journeying in Europe under the guidance of a tutor who no doubt requires each of them to take full notes and to prepare theses on the various features of municipal engineering studied. While our correspondent fails to specify what text books were taken on the trip for preparatory and collateral study, we presume that the list included the most recent works of the recognized highest authorities; and that the time on the trip across was divided between the study of those texts and lectures by the instructor, instead of being wasted at shuffleboard, in lounging room stories, or similar frivolities indulged in by the average unintellectual pleasure-seeking, transatlantic voyager.

The value of this schooling will of course be inestimable, and not at all to be measured by the $19,500 which it is costing Chicago. It is always well to begin with the hardest part of any task and thus have it over with; and the board of education did well to start this course with a study of complex problems at the points which are hardest of access. Having mastered the problems there found, the simpler problems nearer home can more readily be grasped and appreciated. When the education of the councilmen thus auspiciously begun is completed their services to the city will be invaluable—if they are still in office.

We should note, too, that our former editorial, while crediting the city government with economy in this matter, failed to do full justice, for when we thought that only 18 persons were in the party we gave the cost of each as $1,080. As it develops that there are 19 members, this cost is reduced to $1,026.32 each; or what is a more likely arrangement—$1000 for each student and $1500 for the tutor.

One word more as to the head of the party, and his work. While Mr. Hill will be very busy instructing those under his guidance, he will no doubt add substantially to his own store of technical knowledge, from which addition the City of Chicago will receive the benefit. Some narrow minds may suggest that Mr. Hill could profit more from the trip if unburdened with the care of 18 students, but such a suggestion is hardly worthy of notice. Not only does it indicate a complete failure to grasp the importance of the city's giving a liberal education to its councilmen, so that each of them may cope with the intricacies of technical problems should their engineering force suddenly go on strike; but it shows a downright meanness of spirit much to be deplored in a liberal and generous community like that of Chicago.

Letter to the Editor

Chicago, Aug. 7, '22.

Sir:

Your comment in the issue of Aug. 2, '22, anent a tour of Europe by a group of Chicago aldermen, in search of information on highways, sewerage and other municipal problems, may have ample precedent to justify its humorous tone, but a full statement of the personnel of the party might somewhat blunt the point for a good many engineers in all parts of the country.

Although it is true that City Engineer Murdoch did not accompany the group, nevertheless if your editorial writer had been set to pick any single man who might be expected to supply engineering experience with special reference to Chicago conditions, he could hardly have improved on the aldermen's selection of C. D. Hill, Engineer of the Chicago Board of Local improvements, who is with them.

Very sincerely,

——— ———.

[In deference to the request of the writer, who is one of our subscribers, we withhold his name from publication.—Editor.]

Explosives Statistics for May.—Sales of explosives in May, 1922, for use in the United States increased nearly 3,000,000 lbs. over the quantity sold in April, but were about 4,000,000 lbs. below the record for March. According to reports received by the United States Bureau of Mines from manufacturers, the May sales totaled 23,379,855 lbs., of which 6,858,250 lbs. (274,330 kegs) were black powder, 15,076,048 lbs. were high explosives other than permissibles, and 1,445,557 lbs. were permissible explosives. The total quantity sold in May, 1922, represents a reduction of 10.7 per cent or 2,801,292 lbs. below the sales in May last year, and 45.5 per cent or 19,493,967 lbs. below the sales in May two years ago. Coal mining consumed 70.7 per cent of the black powder sold in May, 3.2 per cent of the "high" explosives, and 83.7 per cent of the permissibles. Other mining operations used 6.8 per cent of the black powder, 39.1 per cent of the high explosives, and 9.6 per cent of the permissibles. Railroad and other construction work required 10.1 per cent of the black powder, 12.6 per cent of the high explosives, and 0.2 per cent of the permissibles. Miscellaneous classes of work consumed 12.4 per cent of the black powder, 45.0 per cent of the high explosives, and 6.5 per cent of the permissibles.

Planning Transit Developments for Cities

The fundamental basis of a proper transit development is that city transit should precede, not follow, the population, states Daniel L. Turner, Consulting Engineer, Transit Commission of New York City, in a paper presented June 6 before the National Conference on City Planning. This principle means that when it becomes necessary to open up a new area for the growing population, the transit system and the street system should spread out over the new territory simultaneously; the two systems should expand together. Then the other services, such as water, sewers and light can follow. Further extracts from Mr. Turner's paper follow:

When a City is Conveniently Served.—It may be assumed that a city will be conveniently served if a prospective passenger is not required to walk more than ¼ mile—or walk longer than 5 minutes—to reach a surface line, either a motor bus line or a street railway line, routing towards the business center, which is the objective point for most of the traffic. This means that the lines would be about ½ mile apart in the residential districts. For crosstown service, lines 1 mile apart will conveniently serve the community.

In the case of subway or elevated lines, that is, rapid transit lines, if the lines routing to and from the center are 1 mile apart, and the crosstown lines are 2 miles apart, convenient rapid transit service will be afforded the community; everyone could reach a rapid transit line within a ten-minute walk. The surface lines and the rapid transit lines would route closer together than described above as they approach the business center, to the extent of traversing every street in extreme cases.

Route Mileage Based on Semi-Circular City.—A study of most of the larger cities indicates that they conform closely to the semicircular shape and can be included within a 6-mile radius. For this reason an analysis of the route mileage standard can be based on the theoretically semicircular city. Such a semicircular city of 1 mile radius contains an area of approximately 1,000 acres, and the area increases as the square of the radius; so, squaring the radius in miles and multiplying by 1,000 will produce the approximate acreage of any semicircular city. Upon this basis, it would require approximately 1 mile of motor bus or street railway line, or route, for every 200 acres of city area. In the case of a single track, with the average sidings, this would reduce to 1 mile of single track for every 180 acres; or in the case of a double-track line (neglecting yards, etc.), one mile of track for every 100 acres. Usually the acreage served by 1 mile of track should be between these limits.

Standards for Rapid Transit Line.—For rapid transit lines the corresponding standards are: One mile of rapid transit route for every 400 acres of city area; and 1 mile of rapid transit track for every 200 acres of city area, assuming a two-track line. The next important factor is the routing of the transit lines, or number of routes. By a route is meant a continuous line, either from the business center to the outer limits of the city, or crosstown (or circumferentially) from one side to the other of the city.

In the former case, such a line would serve a strip of territory ½ mile wide for a motor bus or surface line and 1 mile wide for a rapid transit line, and would connect the residential section traversed directly with the business center; in the latter case, a crosstown strip 1 mile or 2 miles in width would be served, by surface and rapid transit lines respectively, thereby conveniently connecting every part of the city with every other part, with one or two transfers.

The number of routes is another measure of the accessibility or convenience of the service. The theoretically semicircular city again will be used as the basis for determining the standard. For motor bus lines and surface car lines approximately the number of routes can be obtained by extracting the square root of the city acreage and dividing by 6.3. For rapid transit lines, the square root of the city acreage divided by 12.6 will give the number of routes approximately.

Distribution of Transit Routes.—The routes should be distributed throughout the city so as to furnish the same character of service to all sections. The up-and-downtown routes should be as direct as possible. Their function is to provide quick transportation between home and work. As far as practicable, up-and-downtown routes serving opposite sides of the city should traverse the business center crosstown-wise through the same street. In this way one pair of tracks in the congested area would accommodate two pairs serving opposite residential sections; that is, for every four outlying tracks only two tracks would be required through the business center. In the morning and at night both such tracks would be utilized by loaded cars with workward-bound passengers in the morning and homeward-bound passengers at night. This constitutes the development of a two-way traffic through the business center and consequently is the most economical use of the streets within the congested area.

Ideally arranged, the central pair of up-and-down routes would penetrate farthest downtown, across all of the crosswise business streets, except the one nearest the water-front, which would be traversed by the crosstown connection for two-way traffic above described. Thus the movement of the cars would be along a U-shaped route downtown on one side, across town through the business center and then uptown on the other side. The pair of routes next removed and on either side of the central pair would continue downtown as before across all of the crosswise streets to next to the last one. With this route arrangement a passenger could reach almost any point in the business section by one transfer from his own up-and-down line.

The cross-town lines are for a different purpose. They will be used by transfer passengers chiefly. They should run directly across-town and thus intersect all up-and-down lines. Their function is to articulate the entire railway system. By means of them a passenger will be able to reach any point in the city from any other point.

Engineering Employment Situation as Noted by the American Association of Engineers

A gradual and steady advance in engineering employment in all sections of the country with increased activity in many basic industries is reported by the employment department of the American Association of Engineers. The building industry has been most active. There have been some irregularities in manufacturing. The coal mining and railroad fields show a slight setback, due possibly to labor difficulties, but technical men are in demand. Highway and municipal work are progressing with added vigor, and employers in these fields find it difficult to locate experienced men. The demand for architectural and structural draftsmen and designers with building or plant experience has far exceeded the supply in practically all sections of the country.

Employment conditions for engineers in most territories are normal or very nearly so. The Southwest reports a scarcity of mechanical and structural men. California reports that students for summer employment are the only men available. Missouri reports normal conditions with calls for structural engineers predominating. Employers in eastern cities where usually more men are available are experiencing difficulty in finding capable engineers, with the possible exception of the District of Columbia.

The total number of positions being received by the American Association of Engineers is over 400 each month, with about 250 of these filled by the Association. This large placement is due to concerted local activity by capable employment representatives. The average monthly salary of all positions filled during June was $192. A number of positions above the $500 mark were filled.

While the general conditions are better at this time than they have been for over two years, there is still some irregularity, but the main trend shows improvement supported by prospects of further gain. Added reasons for more hopeful feeling appear in the continued increase in the operation of the iron and steel industry, the diminishing of unemployment of skilled and unskilled labor, and the active progression of building operation.

There is usually a summer letup in business but this does not apply so much to engineering employment for highway and municipal and other construction work is most active at this time. Authorities on economic problems are predicting that there will be considerable activity, increased production, and increased work this fall. This month is in the nature of a breathing space during which strength will be gathered for a more decided advance.

The Railroads as Operators of Highway Transport

Presidential Address May 12, at Annual Meeting of National Highway Traffic Association

By Arthur H. Blanchard.
Professor of Highway Engineering, University of Michigan.

One of the objects of the National Highway Traffic Association is to develop the economic efficiency of highway transport. This Association, which is independent in its findings, and composed of all classes of men interested in highway transport and traffic regulations, should look into the future and endeavor to formulate guiding principles and policies which will enable the highway link in our transportation system to be developed on a sound business basis in the interests of the public welfare.

Attitude of Railway Officials Toward Highway Transport.—What is the present attitude of railroad officials in the United States towards the development of highway transport? The answer is not a simple one to formulate as many diverse opinions have been expressed in words and actions. Some of our railroad officials appreciate the intrinsic value of highway transport and have made use of it as a part of their own transportation systems. Others have advocated its development because they appreciate that it is necessary to the success of their business that facilities should be provided for economically transporting goods over highways to be later carried by railways. Others have been concerned regarding the development of highway transport from the standpoint of destructive competition with railroad transportation and have endeavored to curtail its development through legislative action. Others, and it is hoped that there are only a few in this class, have considered the subject from such a narrow viewpoint that they have advocated a curtailment of highway improvement.

The railroads can render valuable service to the public and to themselves by helping to develop highway transport as feeders to rail lines and as extensions of rail service. The railroads can afford to assist in the working out of this problem as some of the basic principles of the economical utilization of highway transport will have been solved only when highway transport service is used to efficiently expand the territory tributary to the railroad lines, to solve the terminal congestion problem, and to relieve car shortage by taking care of the short haul which is now most expensive for the rail lines themselves. A correct and immediate solution of the inter-relationship between these two links of our national distribution system is very desirable in the interests of all concerned. By no means can the railroads afford to ignore the interest they have in the efficient establishment of highway transport as an auxiliary to railroad transportation.

How Railroads Can Operate Highway Transports.—What are the opportunities for the railroad to function as an operator of highway transport?

First, inter-terminal transportation of freight by motor trucks. The advantages of the utilization of highway transport in this connection have been appreciated by railroad officials. It has been established in some cities, the most notable example being in the case of Cincinnati.

Second, intra-terminal and freight yard highway transport. It is believed that the utilization of motor trucks by railways in transferring commodities, especially l.c.l. freight, from cars to shipping platforms and warehouses would materally expedite the delivery of freight and would reduce idle time of cars standing on sidings.

Third, the collection and delivery of freight in municipalities and adjoining areas. This phase of highway transport, if used by railroads, would be a partial development of what is commonly known as the store door delivery plan. The ruling of the Interstate Commerce Commission in the case of the Baltimore development along this line may mean that it is impracticable for railroads at present to utilize highway transport in this manner except on such a large scale that the charge of discrimination in services rendered could not be brought against them. In England, we find a working illustration of railroads functioning as operators of highway transport in this field. One of the most notable examples is the case of the London and Northwestern Railway's comprehensive system of freight delivery by motor trucks in areas with headquarters at London, Birmingham, Manchester, Liverpool and Leeds. This railroad established this service in 1905 and in 1920 was operating over 350 motor vehicles.

Fourth, extension of transportation service through the medium of motor truck and motor bus routes. There are several methods of development practicable in this field. Urban and interurban electric railway lines may logically expand their passenger transportation facilities through the establishment of tributary motor bus routes. An illustration is afforded by the case of the Akron street railway's acquisition and operation of a fleet of motor buses to supplement their traction system.

Motor Transport in Scotland.—Steam railroads may enter this field through the development of intercity and rural motor express lines to carry both commodities and passengers. One of the most notable examples is afforded by the highway transport services of the Great North of Scotland Railway Co., which established its first highway transport service in 1903 and its first motor truck service in 1904. In 1921, this railway company was operating five passenger routes varying in length from 7½ to 19½ miles and seven intercity motor truck routes varying from 9½ to 19½ miles.

Railroads having stations in scenic areas may well give consideration to another branch of the Great North of Scotland Railway Co.'s highway transport service, namely the operation of a motor bus line for tourist traffic from Aberdeen through the lake region of northern Scotland.

The short line railroads, in many cases, are faced with the alternative of suspending steam railroad passenger or freight service or both due to the high cost of operation and maintenance and the low revenues received or of remodeling their transportation systems.

Several methods have been suggested in order that the returns of the investment may be materially increased.

The Gasoline Motor Rail Car.—The gasoline motor rail car appears to have passed the experimental stage. The utilization of this vehicle on short line railways for the transportation of passengers, express packages and l.c.l. freight is a logical economic evolution of railroad transportation methods. The development of feeder service as way stations and extensions of motor rail car service at terminals by the utilization of motor truck and motor bus lines appears logical under favorable operating conditions.

Some short-line railroads may consider it avisable to replace the track with a pavement and operate their private right of way for the use of their own trucks and buses or as a toll road or a combination thereof.

In connection with some branches of highway transport, the railroad has certain economic advantages from the standpoint of overhead expenses. A traffic department is a part of its organization and may be readily expanded to supervise its highway transport activities. The basic principles of management in an efficient railroad traffic department do not have to be developed and the economic fundamentals of the relation between operating expenses and revenues do not have to be acquired at the expansion of either business failures or costly experience. The establishment of highway transport clearing houses and warehouses will usually mean not more than a rearrangement of its shipping and receiving platforms and buildings with an expansion of such facilities as the growth of its highway transport division demands. Garages and repair shops may be combined with locomotive and car sheds. Generally idle real estate is available for administrative offices, storage tanks and other structures as they are needed.

British Railways' Bill.—The future development of the utilization of highway transport by railroads should receive careful consideration from the standpoint of the efficient development of transportation by railway and highway. Railways may seek powers to operate highway transport both in connection with rail transportation and independent thereof. The present Railway Bill, now before the British Parliament, said to be supported by the Northwestern and Midland Railway group, contemplates an extensive development of the utilization of highway transport by railroads throughout the British Empire with the object of securing powers to conduct highway transport of commodities carried or to be carried by railroads or independent thereof. The public should bear in mind that some railroads may have ulterior motives in seeking to secure the right to operate highway transport. An unfortunate retardation of the development of efficient highway transport in a given community might be accomplished by a railroad by elimination of competition either through the control of routes by franchises or through cut throat haulage prices. If franchises are to be granted railroads for the development of highway transport services, such franchises must be safeguarded by regulations covering the service to be rendered.

The probable rapid development of the utilization of highway transport by steam and electric railroads and the fact that two-thirds of the state legislatures will be in session in the spring of 1923 leads to the conclusion that this Association should have an active National Committee, composed of steam and electric railway officials, highway transport operators, motor vehicle manufacturers, economists and engineers whose duty should be to formulate conclusions relative to the opportunities and rights of steam and electric railroads to function as operators of highway transport.

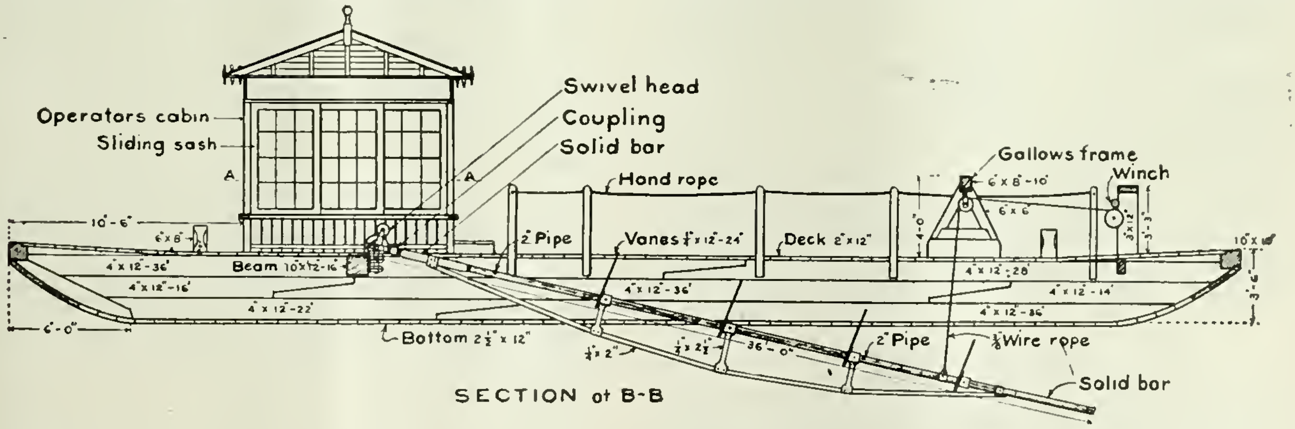
An Autographic Sounding Machine for Profiling River Beds

In 1902 Maj. C. McD. Townsend, Corps of Engineers, U. S. A. then district engineer stationed at Rock Island, Ill., on the upper Mississippi river, conceived the idea of a sounding machine for profiling river beds. It was to consist of a trailing pole connected with a suitable recording apparatus on a barge towed ahead of an ordinary towboat that would give a reliable profile of the bottom for any required distances and that would not materially delay the boat. The scheme was worked out and a practical working instrument produced by M. Meigs, U. S. Civil Engineer. A description of the machine and its use is given by Mr. Meigs in July-August issue of The Military Engineer, from which the matter following is taken.

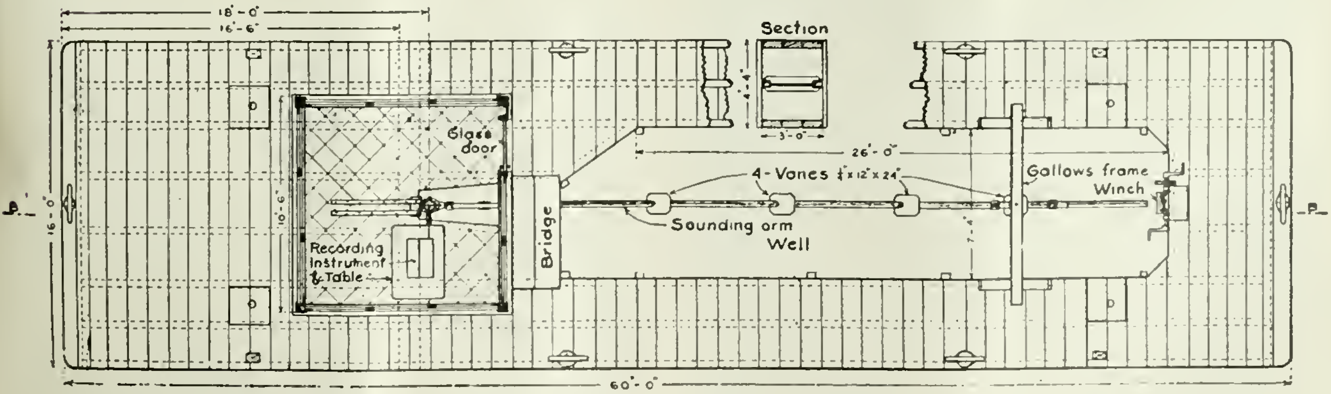
Development of Sounding Pole.—The work was done at the United States Shops at Keokuk, Ia. It was found, of course, that no weighted pole would stay on the bottom in any great depth of water when the boat had any considerable speed, without appliances to hold it down against the upward thrust of the current. The best suggestion for holding the pole down was made by an old pilot, named David Tipton, who proposed a number of wings or vanes attached to the pole which would react on the water and give the needed downward thrust. Experiments made with movable vanes showed that the best angle for the vanes on the 36-foot pole used was 98 degrees with the vanes slanting backward or towards the lower end of the pole. The wings or vanes being set at this angle, the 36-foot pole would touch bottom in 22 ft. of water, which was sufficient for the purpose of this apparatus. The machine was only to be used at the lower stages of the river when depths of 7 ft. or less were to be expected on the bars. A reliable profile of the bottom at low water was wanted, from which to decide where dredging for temporary relief, or works for permanent relief, were needed, and this with the least delay possible.

After determining on the pole best suited to the work, a record machine was studied. In this machine the paper must move forward under the pencil with a steady motion. The drum on which the paper was stretched must not allow the paper to slip, and a certain tension must be kept up at all times. The paper must wind up on one spool and reel off of another, and, as the diameter of the paper rolls is constantly increasing or diminishing in size, some sort of device had to be considered that would act at varying speeds. There must also be a constant tension kept up on the paper so as to make it lie on the drum and keep it running straight. The depth is equal to the length of the pole multiplied by the sine of the angle made by the pole with the horizontal, less a constant figure representing the vertical distance from the pivot of the pole to the water surface. The recording mechanism must imitate on a reduced scale exactly the motion of the pole up and down.

Details of the Mechanism.—The sounding pole carries a quadrant at its upper end exactly 12 in. in diameter. In the edge of the quadrant is a groove carrying a fine, flexible wire cord, which is the means of carrying the motion of the pole up and down to the recording machine. As the pole often takes an angle sideways as well as up and down, provision had to be made that this side angle should not affect the readings on the record. This was accomplished by deflecting the cord from the quadrant on the pole to a vertical direction before leading the cord off to the recorder. A grooved sheave then takes the vertical cord and turns it towards the recording instrument. In this instrument there is a quadrant of the same diameter as that on the pole, and, being of the same diameter, one quadrant follows exactly the motions of the



SECTION of B-B



PLAN of A-A

Fig. 1.—Plan and Section of Catamaran Barge and Details of Sounding Pole.

other. An arm called the "sine arm," attached to and moving with this quadrant, will move through the same angle as the pole. In the instrument being described a "sine arm" of six inches in length was chosen. This arm reduces the motion of the end of the pole in the ratio of 6 in. to 36 ft. or 1 to 72. The "sine arm" is on top of the base with the quadrant below, but they are carried on the same spindle and move together. The outer extremity of the "sine arm" bears against a cross-head attached to a sliding rod made of brass tubing. The tube carries a long flexible spring in its interior that keeps the cross-head always in contact with the end of the "sine arm." The same tube carries the pencil that marks the profile of the river bed on the paper of the recording drum. A stationary pencil marks a continuous base line on the paper while the moving pencil marks depths. This stationary pencil can be set either at zero or at the water surface point.

From this line the depths are scaled. It is usual to stop the boat at bench marks along the route, usually about 10 miles apart, and at these, water surface elevations are taken which enable the stage to be written in on the water surface line. It is possible to add stationary pencils or pens that will rule the record into lines of any depth apart, say every 5 feet, but it is the custom to rule such lines, except the base line, after the record has been taken from the roller. The sheet of record paper is drawn onto the wind-up spool by means of a small weight wound on a 1-inch diameter spool. The extreme travel of the weight is limited by the depth of the barge; hence, as the spool revolves six times to one revolution of the drum and the extreme travel of the weight is about 66 inches, the spool has to be wound up about every 40 minutes.

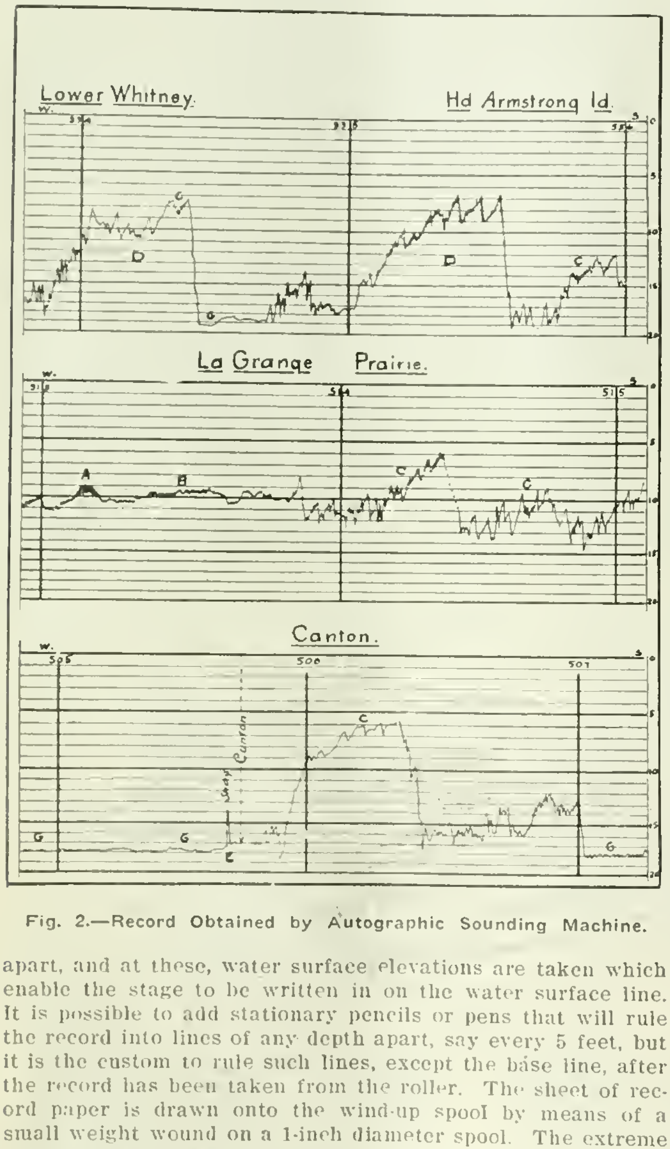


Fig. 2.—Record Obtained by Autographic Sounding Machine.

The time varies according to the diameter of the paper on the wind-up spool and diminishes as the size of the paper roll increases. The above considerations, therefore, necessitate frequent winding, during which time the paper on the drum is stationary. In order to quicken this process of winding, a second spool and cord are arranged in the manner of a Swiss clock, which winds by pulling a chain. This acts so quickly that no sign of it appears on the record. While the weight is being wound up the roll of paper and its spool would unwind if no provision were made to the contrary. On the end of the paper spool shaft is a grooved pulley surrounded eccentrically by a stationary ring, and between the ring and the pulley a small steel ball is inserted. This ball by gravity is always in contact with the rings of the pulley. It acts like a ratchet and pawl and prevents the slightest motion in reverse direction depending on which side of the pulley, the ball is set. By moving the ball over the top of the pulley, the ball becomes a ratchet in the other direction, and this makes the machine truly reversible.

The record drum is 19 in. in circumference and is attached to the minute hand spindle of an ordinary alarm clock; hence, it makes one revolution per hour. The weight and cord serve to draw the paper along by winding the receiving roller, and it overcomes all the friction of the different spindles of the machine. Hence the clock work has nothing to do but hold back, and very little power is required from the clock, which alone would be unable to run the machine. It is attached only as a governor, and a very cheap clock works will do good service and give a steady rate to the record. To prevent the weight pulling too hard on the paper and the clock, there is an adjustable spring brake on the right hand end of the paper spindles. This brake is adjusted by a thumb nut and bears on the wind-off spool so as to allow just the proper pull on the paper. It has occasionally to be adjusted as the rolls of paper change in diameter.

On the drum are rounded pegs which match holes in the record paper exactly as in the films of motion picture machines. These holes prevent the paper from slipping on the drum and changing the longitudinal scale. Paper to fit the roll can be had of dealers. The sheets are perforated with holes on each edge, ½ in. apart. If desired the rolls of paper may be a good quality of tracing paper. If this is used duplicate copies of the record may be had at any time by blueprinting.

The Device in Operation.—Figure 1 shows the catamaran barge on which the sounding pole is mounted. The barge consists of two pontons, each 60 ft. long and 4 ft. 5 in. wide, 3 ft. deep, united at both ends. A portion at each end is decked, and on the forward end is erected a small glass cabin for sheltering the observer in charge. The whole barge is 16 ft. wide. On the after deck is a small winch for raising the pole when not in use. The cabin affords a good view in all directions, independent of wind and rain. The observer sits at a table with the apparatus before him. He has also a map of the division under survey in view, and, as the boat moves along the channel and the profile is drawn, he notes position from objects on shore. These may be any known objects such as ends of dams, light house beacons, ends of islands and the like. Thus, the location of any bar can be very closely fixed.

The drum of the machine being 19 in. in circumference and making one revolution per hour, if the speed upstream be 5 miles per hour, the longitudinal scale becomes 3.8 in. per mile. A slower speed gives a longer scale and a greater speed a shorter one, but this scale is about the same as the district map used for location and is found large enough to show well all inequalities of the bottom. To get a larger vertical scale, a longer "sine arm" may be used, but the scale as fixed in this instrument has been found about right for this district and accurate enough for all purposes.

To use the machine, the operator first hoists the pole to a horizontal position parallel with the water. He then adjusts the cord from the pole by means of a small turnbuckle, so that the "sine arm" extremity is on a line square with the sliding rod. There is a mark on the slides under the cross-head showing this position. All the operator has to do is to tighten or loosen the cord until the cross-head comes to this mark. The machine is then ready for sounding. The pole is now lowered so as to touch the water. At the corresponding point on the record a pencil is set to record water surface. If it is desired to get a confirmation of the accuracy of the record, the pole may be lowered 1 ft. at a time and the corresponding lines on the chart examined. This must, however, be done in still water, since it is impossible to get measurements with a tape where the boat is moving and making a current. Care must be taken by the pilot of the towing steamer not to let the boat swing so as to get the pole under the boat. It is also necessary to keep the pole up when backing. With these precautions hundreds of miles can be sounded in a very few days, and a complete picture of the channel depths obtained.

A valuable feature of the profiles made by this machine is that the nature of the bottom as well as the depths is recorded. When rock is struck a peculiar line is traced, easily recognizable from sand or mud. Gravel, sand, mud, rock, all have their peculiar handwriting on the profile. Snags never known to exist show up as vertical lines, large bowlders are located; indeed, the record of the bottom is minute, with every small sand ridge plainly shown. For comparison, long stretches have been surveyed, making simultaneous soundings with a lead or hand sounding pole. The record of these soundings platted alongside the mechanical record nearly always shows more water than the mechanically drawn profile. And it is easy to see on examining the minute irregularities of the bottom shown on the mechanical profile that the hand sounding pole cannot, except by chance, hit the very tops of the sand waves, big and little, which cover every foot of the bottom. The hand pole, hitting the bottom only every one-fourth minute, which is as fast a rate as a man can stand for long stretches, and traveling at the rate of five miles per hour, only gives a sounding at intervals of 110 feet. This is far too seldom to catch the highest points of the sand ripples.

But the work for which the machine was planned was the rapid and accurate tracing of a profile of the bottom along the steamboat channel, and this it does very effectually. A fine thing is that the record, when it is turned in, is complete and a great improvement on ordinary soundings, which require a long time to plat. Also the possibility of duplicating the record by blueprinting has value.

Analysis of the Record (See Fig. 2).—At "A" is rock bottom; at "B" gravel; at "C" sand; at "D" a pair of big sand waves displaced by contraction works above and not yet absorbed and dissipated; at "E" a snag; at "F" mud; at "G" the pole beyond its depth and floating. Not only the character of the record changes with the nature of the bottom but the pole gives out a very characteristic sound for different material.

At "H" a line of simultaneous hand soundings was run which are shown as a dotted line.

In order to make upstream soundings at the rate of 5 miles per hour, it is evident that, with a 2-mile current, the speed may be attained with less difficulty. It is evident that considerable power is required to propel the apparatus. By going downstream, the same speed may be attained with less difficulty. But to pull a 36-ft pole against the current sets up a very considerable drag, especially since the pole is equipped with vanes of large surface.

The machine does best with a steamboat that will furnish quarters for the operator when on long trips. Recently this machine was used to make a continuous profile from Alton, Ill., to Keokuk, Iowa, a distance of 166 miles. The record secured was compared with a previous one made over the same distance, and the two rolls of record when measured only differed in length by ½ in. At places where the channel was found deficient, the record was stopped, the boat backed down for a new start, and another channel was run. The record was again put in motion, and the profiles appeared platted side by side in the most satisfactory manner. It is thought that this machine is deserving of wide use, and many occasions may be found where it could be profitably employed.

55% of Levee Work in Louisiana Done by Power Driven Machinery

The earth utilized in building the levees of Louisiana by the Levee Districts, and the State, during the past two years was moved mostly by power driven machinery, according to the report of the Board of State Engineers for the period April 20, 1920, to April 20, 1922. This method still stood first in place and volume of work performed; that performed by scrapers drawn by mules, second, and by men with wheelbarrows, third, as shown by the following:

By power-driven machinery, 55 per cent; by scrapers drawn by mules, 44 per cent; and by men with wheel-barrows, 1 per cent.

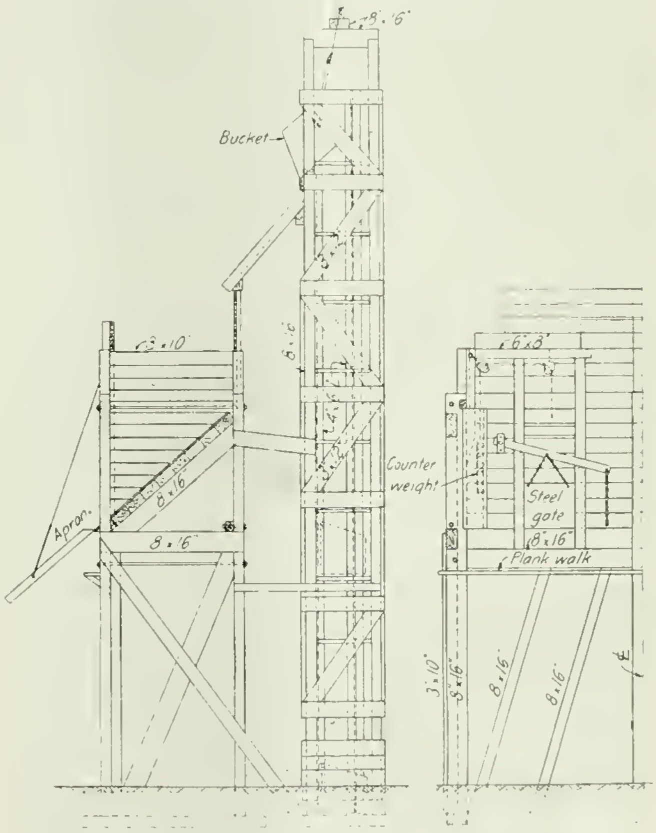
The average cost of the levee work performed by the Levee Districts and the State, by all methods, during the past two years, was 34.57 cents per cubic yard, and by the three methods named, as follows:

By power-driven machinery, 33.60 ct. per cubic yard; by scrapers drawn by mules, 36.18 ct. per cubic yard, and by men with wheel-barrows, 38.30 ct. per cubic yard.

Coaling Station Built of Used Materials

At Bartlett, just outside of Peoria, Ill., where the Minneapolis & St. Louis Ry. has its eastern terminal yard, this company built a coaling station last year which, aside from a somewhat novel design in coaling station construction, embodies the interesting feature of having been erected by the bridge and building forces almost entirely from second-hand 8-in. by 16-in. bridge timbers. We are indebted to the Railway Maintenance Engineer for the details that follow.

Only a small structure was required at this point for the reason that the daily consumption of coal did not exceed an average of 30 tons, the road engines, taking enough coal at a main line station about 20 miles away to last them until their return to it, thus leaving only the switch engines to provide for. To meet this situation it was first considered sufficient to build only the elevated bin, which, when erected, was filled with coal by a locomotive crane operating a clam shell bucket. When it developed, however, that the clam shell was often not to be had when desired for filling the bin, it was decided to supplement the bin by the tower equipped with a bucket and hoist as shown on the plan.



General Detail of Coaling Station.

The bin is about 12 ft. long and 9 ft. high. As shown on the plan, the bottom slopes to the front of the bin and interior sidewalls are present to deflect the coal towards two points of discharge where the flow of coal is regulated by a steel gate operated by a lever accessible to the engineman. Each pocket is also equipped with a steel apron properly connected to a counterweight so that it may be raised into the clear after the loading of the engine. The bucket for the coal hoist is a ¾-yd. iron receptacle so attached to the hoisting rope that when reaching the top, it is tripped into a position permitting the contents to dump into an apron discharging into the coal bin after the manner of more elaborate facilities.

The hoist is operated with an ordinary bridge builders' hoisting engine, the steam for which is obtained from the water station pumping plant in the vicinity. The coal is delivered at the foot of the tower from side drop bottom coal cars, which are dumped to the side of the track next to the tower. These cars discharge about two-thirds of the load close enough to the foot of the tower to enable the laborer to transfer it into the bucket without taking more than a step.

Novel Method in Pile Driving

An ingenious method was devised by Allen N. Spooner & Sons of New York City for driving piles at the Hackensack freight bridge of the Pennsylvania R. R. This is a double track bridge carrying the east and west bound freight trains of the Pennsylvania R. R. An extra bent of piles was driven inside of the old bent, one new pipe being driven alternating with each old pile. Piles were driven on each side of the bridge and also driven between the tracks. On account of the heavy traffic, the use of a batter frame would have been too expensive, and as piles had to be placed in and close to signal box platforms, a batter frame could not have been used in such places; the risk of breaking the signal boxes would have been too great.

These conditions were successfully overcome by A. N. Spooner & Sons. The drop hammer of the pile driver was fitted with a boom foot piece in which was stepped a boom 50 ft. long, made of 12 in. x 12 in. timber. The drop hammer could be held at any point in the ways, giving whatever clearance was required for the boom. The topping lift line was made fast to the head of the pile driver frame, passed through the topping block on the boom, then through a guide sheave in the frame to one of the drums of the main engine. The hoist line was also operated by one drum of the main engines. Block and fall tackles rigged between the boom top were carried one to each side of the machine and hooked to rope slings carried around the cross ties of the track. The ropes from these tackles ran through guide sheaves, one on each side of the hammer frames, to winchheads of a swinging engine on the deck of the pile driver. This was a Lidgerwood Mfg. Co. engine with double 8¼ in. x 8 in. cylinders, without drum, having two clutch winchheads. The boom was swung in either direction by the winchheads, and could be held fixed in any position. A steam pile driving hammer was used. To clear the track for passage of trains, the steam hammer was lifted and placed clear of the track, the blocks unhooked from the rope slings and carried clear of the track. This was the work of a minute.

Driving Pile Between Rails.

Piles were brought on a barge alongside the derrick barge. The boom swung and picked up a pile from the barge and spotted the pile wherever desired. It then picked up the steam hammer, held it in place until the pile was driven, then placed the hammer between the two tracks and repeated the operation. The swinging of the boom, and holding it in position while the pile was being placed and driven was under absolute control of the operator. This was important as piles were being driven in and around the signal box platforms, and if either the pile or hammer was not handled with exactness, the signal box would be smashed, with the resultant tie-up of traffic.

Placing Pile with Boom.

The piles were 85 ft. in length and they were driven 30 ft. through hard sand and clay. The boom reached a full 50 ft. radius, placing and driving the piles on both sides of the bridge. Thirty piles per day of eight hours were driven on the average, the work being repeatedly stopped and tracks cleared for the passage of the trains.

The main engine was a Lidgerwood double 12 in. x 12 in. cylinder two-drum engine and boiler, with extended shaft and winchheads in front, installed for operating the regular drop hammer. The Lidgerwood winch engine was installed later to take care of the swinging of the boom. It was supplied with steam by the boiler on the main engine.

The Geophone in Mine Surveying

Geophones, according to the U. S. Bureau of Mines, supply a quick and fairly accurate method of mine surveying. If two tunnels were being brought together from any direction, the progress of the tunnels could be observed by means of the geophones, and their relative positions determined.

Another application of the possibilities of the instrument in mine surveying is in the prevention of accidents in blasting through. If two tunnels are approaching each other, or are passing a short distance apart, it is necessary to determine the relative location in order that men may be warned to keep away from the point of danger. As the sounds transmitted through the geophone are so characteristic, frequent observation would enable a trained observer to follow the progress of the work in the opposite tunnel. He would thus be able to tell when blasts were to be fired.

Occasionally churn-drill holes are dropped from the surface to mine workings for running pipes and for ventilation. When these borings come for considerable distances they sometimes drift, and instead of breaking through into the workings, they come down into the solid. The question then is to locate them and to determine whether or not the hole is deep enough to come into the workings. Here the geophone finds a useful field, for not only the direction of the hole, but its elevation can be determined accurately.

It is well known that when the bit of a diamond drill has disappeared below the surface there is no simple method for determining the course it may have taken. As these bits nearly always drift away from a straight course, any instrument making it possible to follow this drift will obviously be valuable.

Crushing Plant Engineering

Principles Discussed in Paper Presented at Last Annual Convention of National Crushed Stone Association

BY BROWNELL M'GREW,
Engineer, Allis-Chalmers Manufacturing Co.

There is probably no branch of industrial engineering in which the individual judgment and "common sense" of the engineer are of greater importance than in the crushed-stone industry.

Naturally, there is considerable difference of opinion as to what constitutes "common sense"; it is not surprising, therefore, that there is a considerable difference of opinion as to what constitutes good crushing plant engineering, particularly in view of the fact that there is no fixed standard or criterion by which to compare one crushing plant with another.

Furthermore, crushing practice has gone forward by leaps and bounds in the past two decades, and what was good engineering in the light of yesterday's experience may not be good engineering in the light of our present-day knowledge.

There are, however, a few sound basic principles upon which all successful engineering must be based, a few standards that any efficient plant must measure up to.

Effectiveness of Operation.—The first of these—effectiveness—is the most important measuring rod that can be applied to an industrial plant of any kind.

Will the plant do what it was designed to do?

As regards the crushing plant effectiveness bears directly upon capacity for one thing, and here we have one of the greatest stumbling blocks for the unwary designer.

Adequate capacity must be provided for throughout the plant; in the main breaker, the secondaries, screens, elevators, hoists. Not only must the plant be capable of crushing a certain tonnage in a given time, but it must also be capable of reducing the stone to marketable sizes and properly separating, grading, and perhaps remixing certain sizes.

The demand for clean stone, properly graded, is becoming more and more insistent, and the wise operator is putting his plant in shape to meet this demand. Likewise there is an ever-increasing demand for the smaller sizes of crushed stone for reinforced concrete work, highway binder, etc., and the modern commercial plant to be fully effective, must be prepared to deliver these grades in large quantities.

The Primary Breaker.—Ordinarily when plant capacity is mentioned the mind jumps instantly to a consideration of the proper size of primary breaker, for there is probably no one factor in a crushing plant that has so far reaching an effect, from a dollars and cents standpoint, as this machine.

Aside from the element of capacity the size and type of primary crusher influences directly practically every unit in the plant that follows it, and frequently the disposition of these units.

Looking at it from the plant side the most economical breaker is the one that will deliver to it the smallest product—and a product that is relatively free from slabs and fines. Looking at it from the quarry side the most effective crusher is the one that will cut to a minimum the cost of drilling and shooting.

Herein lies the chief advantage of the big receiving opening.

Mr. Edison's line of reasoning when he first developed the Edison roll crusher was as follows: "A pound of coal and a pound of dynamite have approximately the same potential energy value, but a pound of dynamite costs from eighty to one hundred times as much as a pound of coal; therefore why not do as much of the work as possible with coal rather than with dynamite?"

The development of the large crusher and the introduction of the steam shovel into quarry operation are without doubt the two most important improvements that have been made since the inception of the industry, and it is safe to say that development along these lines has not yet reached its limit.

On the other hand, it should be remembered that for any given set of conditions there is an economical limit to the size of primary crushers. Figuratively speaking, one must stand in the middle of the proposition and look both ways. On the one side we have the very enticing possibility of making a substantial cut in the cost of quarrying; on the other we are checked by the factors of first cost, power, upkeep, ratio of reduction, etc.

Location of Plant.—The relative effectiveness of a plant will also depend to a very considerable extent upon its location

Primarily this involves the problem of quarry transportation, of getting the stone from pit to plant as cheaply as possible.

Second only to this in importance is the problem of getting the stone away from the plant and of providing ample storage room for both empty and loaded cars.

It is frequently the case that a location which is advantageous from a standpoint of transportation in the quarry will complicate the handling of the railroad cars, even to the extent of necessitating the use of a locomotive to do the loading.

You will, of course, wish to avoid this when possible; nevertheless it should be remembered that the ton-mile cost of handling the finished product in railroad cars will be very much lower than that of making long hauls in the quarry.

Furthermore, in large commercial operations the locomotive is sometimes necessary—or at least very expeditious—for loading mixed sizes and cutting out required types and capacities of cars needed to fill certain orders.

Flexibility of Operation.—Effectiveness is also the measure of a plant's ability to operate continuously throughout the season with a minimum of breakdowns or delays from other causes.

Rugged and dependable machinery is the best safeguard against breakdown, and a simple layout, comprising the absolute minimum number of units necessary to do the work is the best safeguard against minor delays and accidents.

A principle of crushing plant design second only in importance to effectiveness is that flexibility which, in its broadest sense, is the measure of the plant's ability to meet a varying market demand.

Those of you who are operating plants which do not have this element of flexibility have probably experienced more than once the necessity of turning down orders for certain grades of material, while at the same time you were overstocked on other sizes.

I have mentioned before the increasing demand for the smaller sizes of stone, and the necessity of equipping the plant to take care of this demand. I do not propose in this paper to discuss the various types of fine crushers and their relative merits, but I do wish to lay special emphasis upon their value to the operator.

Closed Circuit Principle.—Fine crushing machines should be so located in the plant that any of the coarser sizes which may be temporarily unmarketable may be readily returned to them for re-crushing.

The value of the closed circuit principle in crushing plant design is so well known, and the principle is so generally adhered to that it would scarcely seem necessary to mention it here. Nevertheless there are still a rather surprising number of plants in operation which are wide open on the finishing end.

This is most frequently found to be the case in plants where the product of the secondary crushers is returned to the scalping screens for re-separation, making a closed circuit at this point and sending on to the finishing screens all material under the maximum size produced.

This is good practice in a straight ballast plant, but is hardly excusable in a general commercial mill as all adjustments in product must be made by changing sections in the scalping screens—whereas in the closed circuit plant changes in product can be made while the mill is in full operation.

The Stock Pile.—Most of you, no doubt, are equipped in some way or other to stock such grades as may be unsalable at the time they are made.

The stock pile is coming to be a very necessary adjunct to the commercial crushing plant as there seems to be no other method of adequately taking care of a fluctuating market.

It is but natural, though, that the quarryman should not be inclined to look with favor upon the stocking of crushed stone—not only because of the expense of rehandling, but because stone in the stock pile represents dead capital.

It is not possible in the light of our present knowledge to put up a crushing plant that will entirely eliminate stocking, but it is practicable to so equip the plant that stocking of the larger sizes will be unnecessary when there is a heavy demand for the smaller grades.

Advantages of Electric Power.—The introduction of the electric motor into the crushing plant has been a great boon to plant flexibility; in fact, I do not believe I am going too far when I say that no other one factor approaches it in importance.

The freedom which it allows in the disposition of the various plant units was impossible under the older system of centralized drive. Nowadays the designer can arrange his machinery with very little thought of complications in power transmission by adopting the group or individual drive—thus sidestepping one of the greatest checkreins upon flexibility.

How Simplicity in Plant Design Is Attained.—Broadly speaking, simplicity in plant design is attained in two ways: First, by reducing the number of units to a minimum, and, second, by simplifying the arrangement of these units and their auxiliary equipment.

A crushing plant is not merely an aggregation of machines—it is in itself a machine—dependent upon the efficient operation of its parts for its success as a whole.

Every part added to a machine and, likewise, every machine added to a plant entails additional power and upkeep expense, and other things being equal, the plant with a few large units can be operated more economically than the one which is made up of a large number of small units.

I would not advocate that this principle be carried out at the sacrifice of flexibility, nor would I wish to set it up in opposition to the independent two-unit plant, which in my opinion constitutes a great feature of modern high capacity plant design.

There is a happy medium which good judgment will point out to the designer for each particular proposition.

Compactness in Design.—Compactness will go hand in hand with simple plant design; its greatest value to the quarry operator lies in the saving of labor required to run the plant—and in the first cost of the buildings that house it.

A plant that is scattered all over a 10-acre lot is naturally going to require a larger operating crew than one that is housed in one building or in two buildings closely adjoining each other.

Like all good things, though, compactness can be carried too far. Accessibility—which is an oft neglected but none the less valuable feature—should never be sacrificed for the sake of obtaining a compact layout or cutting down the size of the buildings.

It would be a very good thing if every man responsible for a "sardine can" plant design could be made to get out and make a few repairs in it on a dark night. There would certainly be some startling improvements along the lines of accessibility in their future work.

The screen house should be large enough to provide plenty of room around the screens; where screens are arranged in battery, room should be allowed for getting at each unit from at least one side.

Elevator pits should be made large and be well lighted, and it is best where possible to arrange for access to the pit from the rear so that the men who have to enter it will not be in danger of being caught in the buckets or struck by falling stones.

Safe runways and stairs should be provided for getting at overhead shafting; only an exceptional man will pay the proper attention to inspection and lubrication when this work involves undue fatigue or personal danger.

Much can be done in the average crushing plant to promote this feature of accessibility—not only as regards repairs, but also with respect to operation.

I have in mind a small plant in the East that was originally designed with the incline directly over the top of the primary crusher and at such a height as to prevent free access for feeding. This plant was equipped with a No. 6 primary machine.

After operating under this handicap for several seasons the incline was shifted to one side and raised so that the feeders were unhampered in their work—and the average output of the plant was increased 50 tons per day.

Selecting Type of Crusher.—The question of selecting the right type of crusher is one of the most widely debated questions among quarrymen and engineers. It is not surprising that this should be so.

My own observations lead me to believe that there have been more costly mistakes made in choosing the type of crusher to be used than in any other branch of crushing-plant design.

I believe we all have a very human tendency to become unduly enthusiastic over the merits of that particular type whose performance has been most favorable in our own personal experience. Also, the introduction of a new type, or its development in large sizes invariably instigates what might be called a short period of "faddism."

I have been fortunate enough during my own erecting and operating experience to come in contact with all of the three general types of main breakers and I will have to confess that, at one time and another, each of the three was a heavy favorite with me.

The truth of the matter is this: Strictly speaking, there is no such thing as a universal crusher. I believe you will all agree with me that the gyratory more nearly approaches this definition than any of the other types, but even the gyratory has its limitations.

The man who is going to put his money into a new crusher will do well to make a careful study of the characteristics of all of them—to check these characteristics against the material to be crushed, the product desired, and the capacity wanted.

Only after such a comparison will he be qualified to make an intelligent selection of the right type for his particular work.

The Flow Sheet.—One phase of crushing plant design that deserves more attention than is generally given it is a study of the flow sheet.

We all know that no two classes of rock have the same fracture and that for this reason a flow sheet can only be an approximation of what will actually take place in the plant. But even this approximation is vastly better than a rough guess, and anything that will help to eliminate guesswork is most certainly a step in the right direction.

The industry in general is in need of more scientific plant design—of a discarding of many of the old rule-of-thumb methods in favor of more systematic methods.

The older and more experienced engineers carry in their memory certain more or less clearly formulated rules and data which they are able to apply offhand to crushing plant problems as they arise; but the coming engineer is going to need more than that; he is going to need these rules and data and the results of the older engineer's experience in printed form; in order that he may have a starting point from which to carry on.

Such rules as there are to guide the crushing engineer must necessarily be empirical in character, and to be safe they must be based upon data which for any particular formula may take years to compile.

Operators Must Contribute Experience.—These data must come chiefly from one source—from the operator—and anything that can be done to promote closer cooperation between the quarryman, the machinery manufacturer, and the engineer, for the purpose of furthering our present-day knowledge of crushing stone cannot help but benefit the industry.

What I have designated as scientific design should not be confused with conservative design.

It is safe to say that 95 out of every 100 plants represent what might be called conservative design.

Conservatism consists largely in profiting by your own and the other fellow's mistakes, or in a repetition of your own and the other fellow's successes.

Scientific principles will be more in the nature of a guiding light for the progressive quarryman and engineer—the men who are on the alert to try something new.

Civil Service Examination for Appraisal Engineers.—The U. S. Civil Service Commission, Washington, D. C., has announced an open competitive examination for appraisal engineer. Vacancies in the technical staff of the Income Tax Unit of the Bureau of Internal Revenue, Treasury Department, Washington, D. C. at $3,000 to $4,000 a year, and vacancies in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion. Applications will be received until Aug. 29.

Drill Steel and Drill Bits at United Verde Mine

Interesting data on mining methods and contracts of the United Verde Mines are given in the 1921 Transactions of the American Institute of Mining and Metallurgical Enquiries by H. DeWitt Smith and W. H. Sirdevan. That portion relating to drill steel and types of bits is abstracted below.

Drill Steel.—At the present time only two kinds of drill steel are used. These are 1¼-in. hollow round steel for the heavy Leyner type of water drills, and ⅞-in. hollow quarter-octagon steel for the light Jackhamer type and for the wet stoper drills. The size of bits is the same for both kinds of steel. Fig. 1 shows, in tabular form, the standard changes.

The breakage loss is less for 1-in. quarter-octagon steel than for ⅞-in. steel, but this advantage is offset by the greater drilling speed obtained with the ⅞-in. steel in drilling vertical holes. The ⅞-in. quarter-octagon steel gives less breakage than either ⅞-in. hexagon steel or 1⅛-in. cruciform steel. Table I shows the steel breakage for December, 1917, and for a year later, December, 1918, after the adoption of a double-taper cross-bit and steel with quarter-octagon section.

Types of Bits.—Experimental work carried on by H. W. Seamon, the efficiency engineer supervising all drilling operations, has resulted in the following improvements in the drill bits. When these tests were commenced, all Leyner machines used 1¼-in., hollow, round steel with cross-bits of 14° single taper. A 9-in. change in length and a ⅛-in. change in gage from a starter of 2⅜-in. to a finisher (eighth) of 1½-in., were the ordinary changes in use. On account of the rapid loss of gage with a single-taper bit, 1/16-in. changes in gage were unsatisfactory. The double-taper cross-bit, Fig. 1, and the double-taper arc bit were tested in comparison with the single-taper bit mentioned, using six 9-in. changes, with gage ranging from 2¼ in. to 1⅝ in. The results of these tests are given in Table II.

As 75 per cent of development and stope drilling is in massive sulfides, the average increase of 105 per cent. in drilling speed in this formation by the use of the double-taper bit led to the prompt abandonment of the single-taper bit. The theory of the double-taper bit, as developed by Geo. H. Gilman, was fully demonstrated by the foregoing tests under most severe drilling conditions. With the slight difference in drilling speed between the double-taper arc bit and the double-taper cross-bit, the latter was adopted as the standard bit because it is simpler to make and easier to maintain. The tests also led to the adoption of a 1/16-in. change in gage, as noted in Fig. 1. The loss in gage of the double-taper cross-bit was less than 1/16 in. per foot drilled in all ground except jasper. As jasper is encountered only occasionally in development work, this objection was not serious.

TABLE I—STEEL BREAKAGE.

December, 1917:	1¼-in. round.	⅞-in. hexagon.	1⅛-in. cruciform.	⅞-in. quarter-octagon.	Total.
Steel sharpened...	19,227	10,482	4,779	2,978	37,466
Steel broken.......	578	427	296	62	1,363
Per cent broken...	3.01	1.08	6.20	2.08	3.64
December, 1918:*					
Steel sharpened...	28,121	4,256	405	11,471	44,253
Steel broken.......	252	77	34	190	553
Per cent broken...	0.89	1.78	8.40	1.66	1.25

*After introduction of double-taper cross-bits.

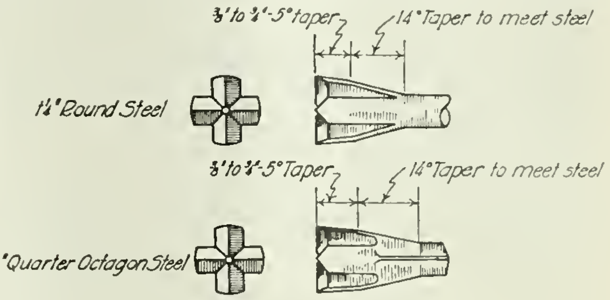
TABLE II—COMPARISON OF SINGLE- AND DOUBLE-TAPER BITS.

Material drilled	Av. drilling speed, ins. per minute.			Average loss in gage per foot drilled		
	Single-taper cross-bit.	Double-taper cross-bit.	Double-taper arc bit.	Single-taper cross-bit, in.	Double taper cross-bit, in.	Double-taper arc bit, in.
Massive sulfides	1.53	3.30	3.05	0.125	0.063	0.078
Jasper	2.65	3.75	4.15	0.156	0.094	0.094
Porphyry	5.10	5.48	5.56	0.031	0.031	0.031

TABLE III—EFFECT OF DRILL BIT DESIGN ON DRILLING SPEED.

	Av. drilling speed, in. per min.			
	1. Single-taper ⅛-in. change.	2. Double-taper ⅛-in. change.	3. Double-taper 1/16-in. change.	Per cent increase in drilling speed 3 over 1.
Massive sulfides	1.53	3.30	4.20	174
Jasper	2.65	3.75	5.20	96
Porphyry	5.10	5.48	7.88	54
Gage of starter, in....	2¼	2¼	1 15/16	..

Table III, derived in part from Table II, shows the increase in drilling speed resulting from changes made in the drill steel, from single-taper cross-bits with ⅛-in. change of gage to double-taper cross-bits with a 1/16-in. change in gage. All holes bottomed at 1⅝ in. after six 9-in. changes. The results obtained by drilling holes of different diameters in the above classes of ground indicate that the drilling speed, in inches per minute, is closely proportional to the area excavated. The increased drilling speed obtained by using the double-taper bit with 1/16-in. change in gage was secured at a slight increase in the cost of sharpening per bit. Several other types of bits have been tried at the United Verde mine, but the cross-bits have given the best satisfaction.



Standard Changes

Steel	Short Starters	Long Starters	Seconds	Thirds	Fourths	Finishers	Long Finishers	Extra Long Finishers
Length 1¼" Rd	12"-18"	18"-27"	27"-36"	36"-45"	45"-54"	54"-63"	63"-72"	Over 72"
Guage	1 15/16"	1 7/8"	1 13/16"	1 3/4"	1 11/16"	1 5/8"	1 9/16"	1 1/2"
Length ⅞" Q. Oct	12"-18"	18"-30"	30"-42"	42"-54"	54"-66"	66"-78"	78"-90"	Over 90"

Fig. 1.

Labor Problems to Be Studied by Engineering Council

Findings in a nationwide survey of the three-shift day in American industry will be placed before the Executive Board of the American Engineering Council of the Federated American Engineering Societies, at a meeting of the Board to be held in Boston on September 8 and 9.

Two reports, dealing with exhaustive investigations of the two-shift and three-shift day problems in numerous industries will be presented. One, prepared by Horace B. Drury, formerly of the faculty of Ohio State University, will describe the extent of two-shift operation in the continuous industries as well as the procedure followed and the results noted by those companies which have changed from the two-shift day of twelve hours each to the three-shift day of eight hours each. Mr. Drury's report will discuss the general practicability of abolishing twelve-hour turns.

Among the industries investigated are the metals, glass and cement, lime, brick, and pottery, chemicals, sugar, salt, petroleum, cottonseed and other vegetable oils, paper, flour, rubber, miscellaneous manufactures, and mines, electricity, gas, water, and ice, transportation, communication, care-taking, and personal service.

A second report on an investigation of the modus operandi involved in changing the operations of a steel plant from two-shirt to three-shift methods will be made by Bradley Stoughton, former secretary of the American Institute of Mining and Metallurgical Engineers. Both investigations are being directed by the American Engineering Council's Committee on Work Periods in Continuous Operation Industries, of which H. E. Howe of Washington, president of the American Chemical Society, is chairman.

Use of Diamond Drill in Oil Prospecting.—Prospecting for oil with diamond drills is being carried on extensively in Washington and Montana, according to F. A. Edson, petroleum engineer of the Bureau of Mines, who recently visited various centers of activity in the Northwest and Middle West. It is generally found to be less expensive to prospect with a diamond drill than by other methods. Mr. Edson has acquired much information regarding the practice of diamond drilling in oil prospecting, which will be used in the preparation of a report on the subject to be issued at a later date.

Drainage of Open Electric Railway Track

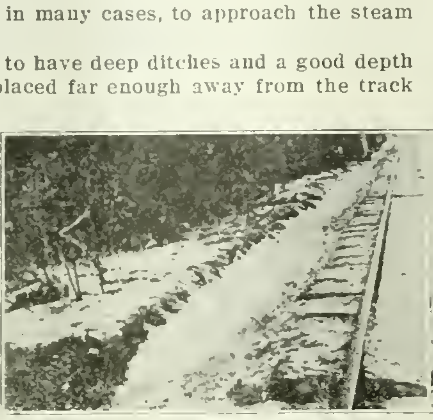
Systems of Track Drainage Described in Paper Presented at Track Maintenance School of Eastern Massachusetts Street Ry. Co.

By R. P. WALLER,
Division Engineer, Eastern Massachusetts Street Railway Co.

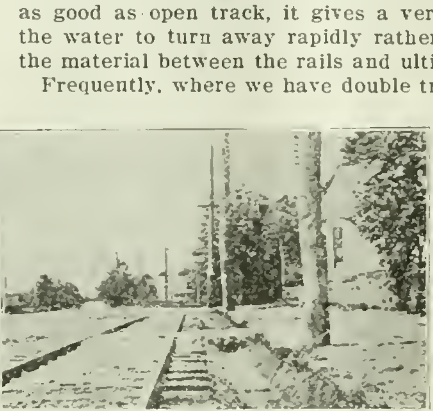
Steam road construction in cuts primarily consists of 8 in. to 24 in. or even 36 in. of crushed stone under the ties; then if the subgrade is not sufficient to insure dry support of the ballast, in some cases a stone fill or kind of telford sub-base is built to make protection for the ballast from the damper subsoil. On each side of the track in worst conditions, drains sometimes 4 ft. or 5 ft. deep are dug, filled with crushed stone and also frequently have an outlet placed in them for drainage.

On electric lines, as a rule, especially in the New England States, this expensive type of construction is not necessary. It is possible, however, in many cases, to approach the steam road construction.

It is always desirable to have deep ditches and a good depth of ballast and ditches placed far enough away from the track as to give a good slope from the end of the tie to the bottom of the ditch. The ditch serves two purposes—one to drain the water from the surface and beneath the track, and the other to intercept ground and surface water that comes from the land away from the track and thus prevent it from getting down under the ties. For this reason, a wide ditch with good slope and a depth below the ties, sufficient to prevent ground water from rising again to the bottom of the ties, is most necessary.



Side Ditching and Cross Drains Along Tracks in Marshy Land.



Open Ditch Alongside Track, Showing Culvert Under Driveway.

Ballast Similar to Steam Road Practice.—On electric lines, the ballast should be, if advisable, similar to steam road ballast, but of the different kinds, crushed rock is desirable. Medium sized stone that will pass a 1⅛-in. ring is generally considered the best size to work with and also allows adequate drainage. Next to stone ballast, coarse, clean gravel is most desirable. Particular attention should be paid not to have too large a proportion of sand and to have all material free from loam, clay or any other substance that will be inclined to hold the water. Cinders can also be used to advantage, but it is found that this type of ballast is harder on the ties and frequently it takes considerable time to get the track down to proper, permanent surface.

On our lines on the Lynn Marsh, the advantage of good drainage is especially plainly seen. Here the track is on a gravel fill, well above the surface of the marshland. Any water that falls on the track or adjacent to it either sinks down from the surface immediately, or if it runs on the surface, has only a short distance to go before it drains over the shoulder of the fill.

Drainage of Tracks Along Highways.—When it comes to building track alongside of the highway, in most cases a street railway has very difficult conditions to face. The highway commission usually insists on the top of the rail being placed at least level and usually slightly below the edge of the road, which makes it almost impossible to protect the track from water. We have this year, however, an instance where track alongside of the highway has been built well above the surface of the highway on good gravel ballast, and we feel that here has been constructed a piece of track that is as nearly ideal as conditions will allow in Massachusetts. The ballast is at least 6 in. above the surface of the road and there is every opportunity on the field side of the track to place a good, substantial ditch so that there will be no reason for water to cause the ballast to settle or shift.

Where our open track changes to a full backfilled track, the troubles that accompany this second type of construction are readily seen. Water is held in the material between the rails, which must lie there until it evaporates or sinks down slowly past the ties into the ballast and sub-grade below before it goes away from the track. This is a slow process and much harm is done while it is in progress.

Much of our track in the last two years that was full backfilled has been changed to half open construction. This type of construction consists of filling the space next to the road rail level with the top of the rail and sloping the backfill off until it comes to nothing at the center of the tie and then sloping underneath the ditch side rail so that there is at least an inch between the rail and the filling or ballast, and leaving the end of the tie next to the ditch fully exposed as it is in open track. This type of construction is the nearest approach to open track that is possible, where the track lies close to the edge of the highway, and while it is not as good as open track, it gives a very good opportunity for the water to turn away rapidly rather than to sink down in the material between the rails and ultimately into the ballast.

Frequently, where we have double track along the highway, it is possible to leave the track next to the ditch full open, and the track next to the road half open, so that very good drainage is obtained, except for the rail next to the highway. After this type of track has been down for a couple of years, the advantage between the full open track and backfilled track is plainly seen by comparing rail next to the highway. The rail next to the ditch will almost invariably have good surface and good line with joints well up in their original position; while it is very common to see low joints at almost every rail length along the rail next to the highway, where they are both surfaced at the same time and have had equal maintenance.

Important Features of Construction.—In preparing ditches along the field side of the track, it is important to pay attention to several features of construction. The bottom of the ditch should be at least 6 in. below the bottom of the ties (12 in. to 18 in. is preferable) and should be far enough away from the end of the ties so that at least a slope of 1½ in. to 1 in. can be easily maintained. The side of the ditch on the field side should also have a slope of at least 1½ in. to 1 in., if it is constructed in ordinary style; otherwise, on the steeper slope, the material will be washed down and soon fill up the bottom of the ditch. The advantage of having 6 in. of ballast is quite obvious, where it is desired to have water run away freely along the sub-grade. It is also obvious that ditches at a less depth than 6 in. would tend to let the water in the ditch draw back under the tie where it is likely to reach the ballast before the pressure from the tie is spread out to uniform depth.

In many instances, where the bank on the outside of the ditch is very low, this bank can be cleaned off and a smooth slope from the edge of the ballast or from the bottom of the tie off to some considerable distance can be obtained. This is a great advantage over the ditch if the expense in getting the result is not too great, for the best motto in good drainage is to keep the water moving and to get it away from the track as quickly as possible. Ditching that can be done away with by replacing with a steady slope from the ties is much more desirable. Where ditches cannot be thus done away with because the outside bank is too high, it is frequently possible to cut through the bank with offtake ditches and so approach the condition just described above. These offtake ditches should be placed as frequently as possible. If the bank is not too large, at least every 50 ft. is not too often for these to be placed, and every hundred feet should be a maximum. In no case should water be carried a long distance in a ditch if it is in any way possible to carry it by pipe or otherwise to a safe distance from the track.

Using Cross Drains.—In full backfill track, where the half backfill type of construction is not possible, it is frequently possible to place cross drains which will take water from between the rails in the direction of the ditch. Cross drains should be placed at as frequent intervals as possible. These drains vary in type. The most effective type is where two or three ties are exposed, making a construction for that distance similar to half open track, allowing ample space between the ballast and the base of the rail for drainage.

From this type, down to the cross drain, which is simply a place between two ties next to the rail, allowing water to run along the base of the rail, there is considerable chance for variation, but it must always be remembered in making these cross drains that their purpose is to get the water away from the track and the smaller the drain is the more likely it is to fill up with sediment and become inoperative. Track with the wide cross drains will become dry and in good condition almost as quickly as the half open type of construction.

In this connection, it is well to note that the cross drains are, without exception, opposite the offtake ditches leading from the main ditch into the fields. This allows the water in the middle of the track to run directly away from the roadbed and does not make it necessary to have it turned at an angle in the ditch and then at another angle farther along, but will leave the ditch; in other words, the water is kept moving and is taken away from the track as quickly as possible.

Pipes at Driveways.—Another important feature of good drainage is the placing of adequate pipes at driveways. We frequently see good ditches for considerable distance along the track until we come to a driveway where the water backs up and is made into a pond, because no means have been provided to get this past the driveway. This is a serious mistake, and in all such cases, galvanized iron culvert pipe of sufficient capacity should be provided to carry the water under the driveway.

On double-track work with center pole construction we have a piece of track which clearly shows the advantage of open track as against full backfill. The inbound or southbound track is full open while the north or outbound track is full backfill. The inbound track is close to the edge of fill so that water getting into the ballast has plenty of chance to drain away rapidly, while the outbound track has a rolled backfill and there is a ridge of dirt from 12 to 18 in. high and from 3 to 4 ft. wide between the two tracks. This holds the water so that there is not easy drainage for this inside track. As a result, every outside rail is in very good surface, while the inside track is heaved and falls out of line to a very noticeable extent and much more maintenance is necessary to keep it in equally good condition. This trouble could be largely done away with if the dirt between the tracks was leveled off and the inside track made half open, but if this were considered too great an expense, a ditch of sufficient depth for drainage could be run along the inside tracks next to poles with here and there offtake ditches, boxes or pipes run under the inbound track so that the water could be carried over into the swamp.

Provision for Run-off at Bottom of Slopes.—It is frequently seen on rainy days, as one rides along country track, that no means are provided at the bottom of slopes for water to drain off. Sometimes, because the track is going through a narrow cut, ditches put along the hill side are not practical, but the water which runs down the track in consequence of this lack of ditching should be drained off at the very earliest opportunity farther down the hill, and this is frequently neglected.

In city track, the placing of catch basins is of every importance to the life of the track and maintenance of equipment and careful attention should be paid to it. On flat grades, catch basins should not be farther apart than 250 feet, if city catch basins can be found within that distance to drain to. The catch basin, when placed in the track, should be below the groove or tram of the rail head, so that water running down along the rail will be intercepted and not carried by a catch basin. If a half grooved or guard rail is being used, provision should be made to either grind away the groove of the guard to allow the water to escape or to have the groove of the guard drilled with sufficiently large holes to allow the water and dirt which is carried by it to drain out into the catch basin.

Types of Tie Tampers Used.—We have two types of tie tampers in operation. One is the electric tamper, which is operated by current from the trolley wire which passes into a box where there is located an automatic switch which operates when the trolley pole is put on and off. From this switch, the current passes into a rotary converter and from there into a transformer and passes out into cables at 110 volts, which is a very safe voltage for men to work around. This current passes into the electric tie tamper which is coupled with a motor or rotor. On the shaft of his rotor there is a weight which is unbalanced, which when rotating at a high rate of speed, causes a vibration in the tamper, which in turn is carried down by the tamping part of the ballast. This is a vibrating action rather than a hammering action and causes the stone to settle into place under the ties by a shaking motion.

The other type of tie tamper is the pneumatic tie tamper which has been in use by many roads for a number of years. This is operated by electric or gas power which compresses air to a high pressure, and this air is then carried through lines of hose to the tie tampers in the hands of the operators. Here, by means of a plunger and series of valves, the tamping part is raised and lowered, giving a hammering action. This hammering forces the ballast into position under the ties rather than shaking it into position as in the case of the electric tamper.

The electric tamper, however, as far as we have tried it, seems to also settle the ballast under the ties effectually and it makes little difference which method of compacting is done so long as it is thoroughly done.

It will be necessary to make further comparative tests, however, before we know the electric tamper stands up beside the pneumatic.

In each case, about an equal number of men are required in the crews. The question of their use is simply which is the most efficient machine.

Maintenance Costs Should Be Kept on a Comparable Basis

All electric railway engineers are fond of making cost comparisons and in fact thy are quite necessary if the economies resulting from attention to detail in the various classes of work are to be evaluated. Compilation and comparison of costs furnish a powerful incentive toward increased efficiency, but in order for these to be of value they must include the same items. An example of a variation in practice occurs in the use of the item of carhouse maintenance. Some railways include this item in their rolling stock maintenance costs; others do not. Manifestly this leads to a variation that should be taken into consideration in making comparisons.

The problem of keeping a record of the cost and life of various wearing parts has received considerable attention from equipment engineers. A few roads have reported excellent results from the use of letters or symbols in the accountant's ledgers to designate the several parts of the equipment. The auditor is then in a position to draw off a statement of the quantity used and the cost of any particular part without great trouble. The men responsible for equipment maintenance require such records in order to conduct their work efficiently and the auditing departments are usually ready to co-operate as far as they can. By deciding on a few parts of which individual records are of advantage and then using a system so that these can be conveniently located, accurate cost records can be produced with considerably less work than by keeping individual car records in the maintenance department. If different roads follow the same practice in this particular, their cost figures can readily be compared.—Editorial in Electric Railway Journal.

Labor-Saving Equipment in Maintenance of Way Work*

By ROBERT H. FORD,

Assistant Chief Engineer, Chicago, Rock Island & Pacific Ry.

Time studies of seasonal or extra-gang laborers engaged in similar classes of work made some years ago on various railroads, showed that their productivity ranged from 28 to 33 per cent. Although the regular section organization runs higher than this, the fact remains that on most railroads the productivity of maintenance labor has not been commensurate with that secured in other industries.

Specialization in railroad maintenance has lagged behind nearly all other lines of industry. This is not due to a failure on the part of the railroads to appreciate the importance of such matters but because of the fact that for years the roads have been too poor to be economical, a fact that will as a rule be reflected in more or less expensive methods of up-keep whether on a railroad, in a factory, or on a farm.

The inability to keep pace with science and invention in providing proper appliances to replace obsolete methods and facilities prevails to a marked extent on our American railroads. Working conditions, legislation and higher costs of labor have served to accentuate this of late and as a result changes in methods of up-keep are sure to result. As evidence of this, more attention has been paid and more actual advance has been made in this direction in the last few years than in the previous 20 years and, from every economical and industrial standpoint, this development is bound to continue at an accelerated rate.

Fifty-four Per Cent of Maintenance Outlay for Roadway and Track Repairs.—Last year about 460,000 men were required to maintain the roadways of the United States. Approximately 360,000 of these men performed work that some day will be done either wholly or in part by mechanical means.

To maintain the railroads of the country, vast amounts of labor and material are consumed annually for which there is little or nothing to show at the end of the year. Three hundred and fifty-four million dollars, or about 54 per cent of the maintenance outlay, was for roadway and track repairs, requiring a vast army of men.

Drainage and Ditching.—The roadway must be continually drained and ditched, approximately $31,000,000 being expended annually for these purposes alone. Years ago such work could be done at a cost of from 10 to 25 ct. per cubic yard, while to do the work today in the same manner costs from $0.75 to $2 per cubic yard. If performed by teams, the cost is from $0.50 to $1.75 per cubic yard.

The introduction, a few years ago, of the self-propelled steam ditcher working from a flat car, afforded great opportunities for labor reductions in this direction. One of these machines will perform the work of from 75 to 100 men and reduces the cost enormously. The flat cars have given way to automatic air dump cars with a steam ditcher between them, the machine working from the track and loading and moving the material by a self-propelled device to the point of disposition.

The Ditcher-Spreader.—A comparatively recent innovation in the list of ditching equipment is the ditcher-spreader, equipped with wings similar to ordinary spreaders, but with the addition of a detachable cutting edge so shaped as to form the standard ballast section. This machine not only clears the ditches but it also shapes the sub-grade from the toe of the ballast to the shoulder of the roadbed and cuts and cleans the ditches beyond the roadbed in one operation, leaving a uniform and highly satisfactory appearance. The ditcher-spreader is pushed by a locomotive and will ditch complete from 10 to 25 miles of track per day, completing both sides of the roadbed where necessary. It does the work of several hundred men at a cost of from 2 to 6 ct. per cubic yard. This machine will dig new ditches, but its main advantage is to keep the sides clear of the annual accumulations while the steam ditcher, previously referred to, is most economical in long, heavy or sliding cuts.

Dirt Unloading Equipment.—For years it was customary to use flat cars with a work train, on which the material was loaded by hand or steam shovels and hauled out to the place of use, to be unloaded by means of unloading plows attached to the rear end of the train and drawn through the material by a winding machine. Changing conditions have made this method so expensive and cumbersome that it has now no place in economical maintenance and has been largely replaced by an automatic air dump car, operated direct from the locomotive and loaded by the locomotive crane, steam shovel or other appliances.

The Motor Car.—Although the hand car is an obsolete and expensive factor in railway maintenance, it still continues to be used on a large part of the railway mileage. The section motor car replaces this and has now become an essential for track maintenance, both as a means of economizing labor and reducing expenditures.

Mechanical Means of Replacing Rail.—It has been customary for many years for all operations incident to replacing rail to be done by manual labor, but it is now entirely practical to do the greater part of this work by mechanical means, from the unloading to the final stage of the operation, until the released rail and fastenings are placed in cars ready for shipment. Pneumatic air machines for unloading, operated by two or three men in place of the 15 formerly required, gasoline or electric driven locomotive cranes or small hand-power machines operated by three or four men, will do the work that formerly required 5 to 10 times that number in laying rail.

Power driven pneumatic drills, power bonding machines and power track wrenches are some of the labor-saving devices that operate to reduce the cost of this work and will permit increased efficiency and be productive of great economy in rail renewals. The labor cost of laying rail varies from $700 to $2,000 per mile, the large fluctuation being influenced largely by operating conditions and facilities. A fair cost today is probably about $1,400 a mile. To my mind, the time is not far distant when it will be practical to do this work for about one-third this sum.

A pneumatic air machine, mounted or built on a flat car and equipped with two air derricks, one at either end and placed between two flat cars, will load the equivalent of two miles of rail at about one-tenth of the cost of former methods.

The Locomotive Cranes.—I do not believe that the average railroad man appreciates the wide-spread usage and great opportunity for savings from a properly designed locomotive crane. These machines will do about everything required in lifting, placing, transferring, pile driving, erecting, digging and in fact anything of this class where manual labor has been necessary heretofore. Their activities are predicated very largely upon organization and method of control.

Oiling Machine.—One of the expensive items of roadway maintenance is caused from the deteriorating effect of brine drippings and from salt air in the vicinity of the ocean on rail fastenings, spikes, bolts, tie plates, and even in some cases the rail itself. This requires that these metal parts shall be oiled periodically and the work is usually done by track labor. An oiling machine introduced on the Delaware, Lackawana & Western R. R. by A. J. Neafie of that company has proven invaluable, both as a means of performing the work efficiently and decreasing labor costs.

Weed Killing.—The American railroads spend today about $30,000,000 for clearing the weeds from their tracks, with about $16,000,000 additional to keeping the right-of-way clear of brush and weeds. Track weeds give rise to one of the larger items of roadway maintenance. On important lines it is necessary that they be removed from the track in order that it may be properly maintained. It forms one of the principal jobs of section labor and requires the services of an average of over 100,000 men for five months of the year to clear the American railroad tracks of weeds. A weed burner, operating twice during the season, will remove the weeds at a cost of $14 per mile per trip as compared with $135 per mile for hand labor. This is only one of several devices that is entirely practical for the purpose.

On branch lines the ballast shoulders can be taken care of by the disc weed cutter which operates at a cost of about $4.50 per mile, as compared with $25 per mile for hand labor. Track mowing machines which consist of a sickle bar attached to a heavy duty motor car can be used for this work. These machines operate at a speed of from four to six miles per hour, at a cost of $5.50 per mile, as compared with $40 per mile for both sides of the track by hand labor.

Destruction of weeds by chemicals is both possible and practical although the field is yet open for further development. Here again much remains for the inventive genius.

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*Abstract from a paper presented before the Western Society of Engineers, Chicago.

The foundation for most chemical weed destroyers is arsenic in a soda solution. After a series of applications the interval between applications can be increased and the cost correspondingly reduced. It is possible by annual applications to sterilize the soil so that weeds will not grow.

Tie Tampers and Ballast Cleaners.—Approximately 40 million dollars is annually expended for tamping ties, which is almost exclusively a labor item and is performed by the section and extra gang forces. There are now upon the market tie tamping machines, operated both electrically and by means of compressed air, in some cases the section motor being used to run the compressor. These machines reduce the cost of the work greatly. The tie-tamping machine is a practical, efficient tool. Its use, however, has not become as general as the circumstances warrant.

Ballast becomes foul by use and must be either shoveled out by hand and wasted on the adjoining slopes or cleaned by screening. Many roads do the latter work by hand, using the old-fashioned screen (somewhat similar to a coal screen). Even at that they are enabled to show savings, principally because of the first cost of the ballast. There is now on the market a power-operated mechanical ballast screen that greatly decreases this cost over hand labor and conserves the ballast supply, a matter of special importance in certain localities.

Relative Increases in Wholesale Commodity Prices, Wages and Street Railway Fares

An interesting comparison of street car fares, commodity prices and wages is given by Mr. Walter H. Burke in a recent issue of Stone & Webster Journal. The accompanying diagram shows the relative increases from 1914 to 1921. Regarding these Mr. Burke states:

The upper line shows the relative increase in commodity prices starting with a base of 100 in 1914. The next lower line shows the trend of wages. Both are based on figures published by the United States Government. The lower line shows the average increase in street car fares in all the cities in the United States of over 50,000 population, New York City excepted, the figures being weighted according to population. This line also starts with a base of 100 in 1914 so as to get a direct comparison with commodity prices and wages. In 1915 commodity prices began to feel the effect of the war demand from abroad and increased rather sharply, and by July, 1917, soon after we entered the war, they are 186 compared with 100 in 1914—an increase of 86 per cent. Wages lag behind somewhat, but still are about 30 per cent higher. The lower line shows that street car fares have hardly left the starting post as yet. We are still trying to do business on the basis that prevailed before the war. Skipping along to November, 1918, we find commodity prices at 210, or 110 per cent above 1914, and wages are up about 70 per cent. The street car companies have not been idle though we have succeeded in increasing our prices 15 per cent, while as the chart shows, we are paying an average of some 110 per cent more for the materials we must buy to keep our cars running in order to carry the laboring man, who is getting about 70 per cent more wages than in 1914. And so we go on, with commodity prices showing a tendency to drop a bit immediately after the armistice, until February, 1919, when we start on the secondary inflation as the economist calls it, and we reach a level of 272 for commodities in May, 1920, 172 per cent above 1914, and we find that the working man is getting 130 per cent higher wages than in 1914. The street railway company still is an "also ran"—its prices have gone up only about 25 per cent. Then commodity prices hit the toboggan and we find them down to 175 in January, 1921, with wages only slightly lower than at the peak. The street railway company is still pursuing its nefarious course, however, and we find that we are averaging to get a 48 per cent higher price than in 1914.

The latest commodity figure I have is for November, 1921, and it is 49 per cent above the pre-war level. There have been comparatively few changes in street railway fares during the past year, so it is safe to say that we are about where we were a year ago.

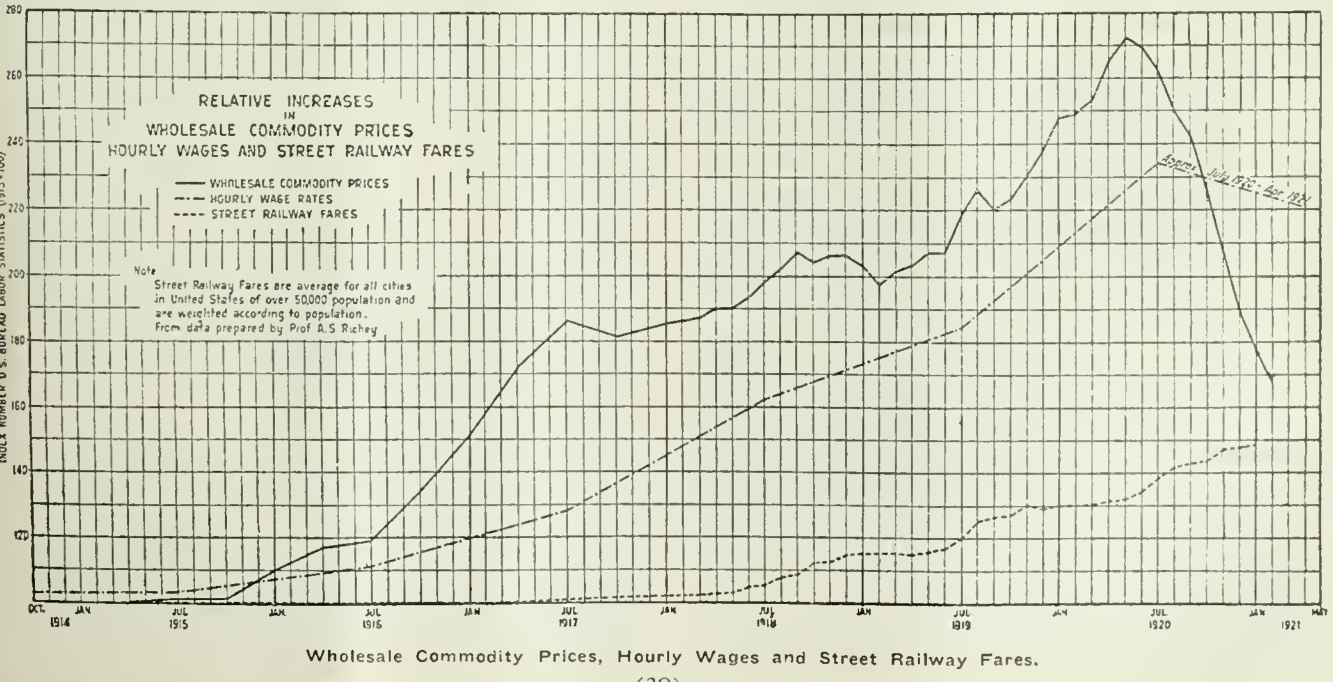
Mines Produce Bulk of Railroad Tonnage

That the railroads of the United States receive from mining nearly six times as much freight as from agriculture, nearly four times as much as from manufactures, and between six and seven times as much as from the products of forests, is developed as a result of a study of the classification of railroad freight tonnage recently made by W. W. Adams, mine statistician of the U. S. Bureau of Mines. The figures show that mining products constitute about 56 per cent of the total tonnage from all sources. The tabulation was confined to railroads having an annual revenue of at least one million dollars, and only freight originating on the roads was included.

In a recent year, the freight tonnages from various sources were as follows:

	Tons.	Per cent of total.
Products of agriculture	115,033,319	10.49
Animals and products	35,493,662	3.24
Products of mines	589,950,958	53.82
Products of forests	94,075,639	8.58
Manufactures	168,759,153	15.40
Miscellaneous	92,798,540	8.47
Total	1,096,111,271	100.00

A large tonnage derived from mineral products is included in the figures shown under the heading of "Manufactures."



Wholesale Commodity Prices, Hourly Wages and Street Railway Fares.

Keeping 100 Trucks Busy

The Consumers Co., Chicago, operates a fleet of over 100 trucks in delivering coal, ice, and building materials. How these trucks are handled was described by David D. Bush, assistant to the vice president of the Consuming Co. in an article in System, from which we have taken the matter that follows.

Accurate Records Kept.—We keep an accurate record of the cost of operating our trucks, and of the performance of each truck. To make this information more valuable to us, we chart it on graph paper. Among other things, our graphs show us the cost of delivering a ton of coal, ice, or building material for each type of truck that we operate the cost of maintenance of each truck; and the average cost of maintenance of each type and make of truck that we operate.

We charge the yards for hauling at the regular union rate. The difference is credited as so much profit earned by the transportation department.

Earnings of the Trucks.—The revenue of the individual trucks—of the larger capacities—figured at the union rate, varies from $25 to $150 a day. Three times in the last year or so we have raised the quota for our trucks, and each time they have passed the quota with surprising promptness. In the last three months we have raised the average earnings of each truck in our fleet by the neat sum of $1 an hour. With some 100 trucks on the road every day, it takes no mathematician to figure out the difference that that means in a month of 10-hour days.

One of the basic rules which we try to keep in mind at all times is that each type of truck must be kept as much of the time as possible on the work to which it is best fitted. For example, we use practically nothing but our 7½-ton trucks, equipped with hoists and dump bodies, for hauling coal in the business district. In this district we are able to load 10 tons on them without feeling that it is an overload, and the manufacturer of the trucks agrees that this is permissible in view of the good roads and the good condition in which we keep our trucks. These trucks have, most of them, been in service for three years; they show practically no wear. That alone bears out our belief that we are not "overloading."

How Idle Time Is Prevented.—We bend our best energies to keeping our trucks on the road all the time; when a truck is traveling it is doing the work for which it was designed. When it is standing still it is, as used to be said of horses, "eating its head off" in depreciation, interest, wages and other expenses.

One of the most effective plans by which we avoid this undesirable condition of idleness is by our schedule or despatch board which hangs in the transportation department at the main office. This schedule board bears the numbers of our various yards; and it operates by means of significantly colored tacks which indicate where each piece of hauling equipment is to be found during the day—horse-drawn vehicles as well as motor.

The Map and Dispatcher System.—A large map of our territory hangs nearby, to show the despatcher the location of each of our yards and garages. By telephone he gets reports on the need for equipment, and conversely the yards where an idle period impends.

The various yards, depots and plants call the despatcher's office in the afternoon and tell their needs for the next day, as nearly as they can forecast them. He makes up his schedule for the next day's work then, and telephones to the garages the assignments for the various trucks which report to them.

In the morning the superintendent of garages reports where all the equipment has been sent; this is carefully depicted on the board by appropriately colored tacks. When, during the day, yard 42 calls up to say that unexpected orders make two more trucks necessary there during the afternoon, the despatcher has only to consult his board. He finds that yard 107 is going to have two trucks idle after 2 p. m. So he calls the manager of yard 107 and tells him to send the two trucks over to 42, which is only three miles away. This sort of transfer takes place many times a day.

We use on our trucks the best equipment that we can find to facilitate loading and unloading.

Rewards of Truck Performance.—We are careful to know everything that we can about the way a truck is performing. Every day the various yard superintendents report on every piece of transportation equipment which was in their service during any part of the day. The report shows the number of loads hauled, tonnage delivered, number of miles covered, loading time, time the truck was taken out and running time of each truck. The despatching department inspects these reports carefully as they come in; the despatchers devote their entire energies to increasing the daily revenue earned by each truck. One of their aims is to keep each truck running out of the same yard all day, unless a load takes it near another yard. For only in this way can the unproductive time on the road be held down to the minimum.

The clerk at each yard keeps a record of each truck working out of his yard; the time entries on these sheets must show a good performance, or else an explanation must be penciled in the margin. When too many intervals appear, the yard superintendent is reminded that it is desirable to keep the trucks on the move. But the superintendent already understands this so well that we have little occasion to jack them up.

This form accomplishes for us what a good many concerns employ a man to do—check up on the trucks when they are out of the yards. We have no men out following trucks; we do not need to know more about the trucks' movements than the form discloses. And the feeling among the drivers is naturally a good deal better than it would be if they felt we employed "spotters." By keeping after the yard superintendents we accomplish better results than we could by the other method.

How Emergency Repairs Are Handled.—We have few emergency repairs to make. And our trucks lose very little time because they are not in running order. We consider ourselves unusually unfortunate if as many as two machines are laid up for repairs, excepting, of course, at the time when we are overhauling. And yet we own over 100 trucks.

We try to catch our repairs before they reach the emergency stage. Our drivers have orders not to drive as much as a block if their trucks show symptoms of serious trouble. And every one of our drivers is enough of an automobile mechanic to know when something is wrong.

When anything goes wrong with his truck, the driver calls the main garage at once. He tells what is the matter; and within five minutes a repair man is on the way to the stalled truck, in a service car in which he has packed the tools or parts necessary for the repair—we keep on hand stock of all parts. As a result of this policy, the truck is usually not laid up for even an hour; and we get many an extra mile out of our trucks, as a direct result of keeping several service automobiles on the job. No Consumers truck ever "limps in" to the garage.

Another step in our campaign to prevent emergency repairs is our method of having the foreman at each garage question the truck drivers as they come in at night, one by one. He asks them about the various parts of the car and how they are working. The driver may not remember offhand the slight engine knock which he first noticed about 4:30; but he recalls it under the foreman's skillful questioning. And the foreman makes a note of each needed repair.

These repairs are made at night; it is seldom necessary to lay up a truck when the damage is caught before it has become serious.

We now have our garage decentralized to 4 points most accessible to our yards. The main garage takes care of all major repairs; and we maintain an average of 3 men for every 12 cars that we store at the other stations. The mechanics go over every car every night, tightening brake-bands, straightening mud-guards, checking up on all little things which may go wrong with a truck, and catching these flaws before they develop into serious troubles.

Besides the mechanics, we have an inspector who makes the rounds of our garages at night, looking over the trucks and seeing to it that none of the maintenance work is slighted. He inspects the wheel bearings, for instance, on every truck.

We have been extensive users of motor trucks now for a number of years. And as nearly as we can tell up to this time, looking after the important points of maintenance and operation makes the truck's life practically unlimited. Some of our trucks have run 170,000 miles and are, as nearly as we can tell, just as good as they were the day we bought them from the manufacturer.

Recent Developments in Gasoline Motor Rail Cars*

BY W. L. BEAN,
Mechanical Assistant to the President, New York, New Haven & Hartford R. R.

Many carriers have lines of road which, on account of traffic diversion to trolley lines, or to highway vehicles, or through other causes of decrease are unprofitable. A great many of the short line railroads are very definitely confronted with a high cost of transportation of passengers, mail, express and baggage. It is immediately apparent to anyone considering this subject, that carriers, in the aggregate, sustain very large losses through the expense of operating the usual steam trains with expenses ranging approximately from 75 cents to $1.50 per train mile and with revenues from 20c to $1.00 per train mile. The expenses mentioned are those for train and engine men's wages, fuel, lubricants, enginehouse expense and maintenance of equipment. Items of interest on investment, superintendence, including dispatching, maintenance of way, signals, stations, station employes, and kindred items, are not included.

Naturally, there are wide differences in the total costs of furnishing service as between different roads or portions of the same road. But when segregation is made of the items accruing to each separate route or schedule, discrepancies between revenues and expenses show that the patrons of the carrier are usually receiving service at less than cost. The excess of costs over revenues is such that usually it would be difficult, if not impossible, to handle the business on any basis of profit. Hence the possibility for many carriers seems to be that of decreasing deficits rather than transforming them into surpluses.

There may well be consideration of desirability of the carriers further developing the actual costs of rendering service on thin lines of road and further acquainting the public and their representatives with the facts. This appears especially desirable with the inauguration of service through the utility of equipment different from that commonly used. The public does not always receive innovations in the best of spirit, consequently, if a clearer understanding of the relation between revenues and expenses could be had, the logic of the situation might appeal. Railroad managements are rightly expected to devise ways and means to reduce transportation costs, but they must receive the co-operation of patrons.

The gasoline engine, as a prime mover for rail equipment use is attracting the widest range of attention from designers and users of equipment and it appears quite clear further development of light railway equipment will be chiefly through the use of gasoline engines, although light weight Diesel type machines may offer competition and also steam which in such use is not out of the running.

As in the case of previous developments of self-propelled rail cars, two forms of transmission of power from the gasoline engine to the wheels and axles are prominent. While gasoline-mechanical drive is at present in the fore-front, there is renewed interest and endeavor to revive the gas-electric system along new lines, embodying lighter construction and less power than formerly used.

Adaptation of Highway Motor Trucks to Rail Use.—Adaptation of highway motor trucks to rail use has been considerable in extent and with generally very satisfactory results. At a reasonable first cost, it is possible to modify a properly designed highway vehicle to adapt it to rail use and to produce a very reliable piece of equipment which will operate at low cost for fuel, oil, and maintenance. The work done by automotive engineers in producing vehicles which stand up under the severe conditions of highway use has favored the operation of practically the same appliances on rails. Skillfully designed clutches, transmissions, gear shifts, etc., employing high heat treated alloy steels; efficient systems of lubrication; light weight parts of great strength, durability and flexibility, have worked out well in rail service. Furthermore, the great extent of use of automotive vehicles for both passenger and trucking service has resulted in a very wide knowledge of automotive design, construction and operation, thereby making less difficult the adaptation of this equipment to railroad service than would otherwise obtain. The usual adaptation of a highway vehicle to operate on rails has been through using the rear pair of wheels to do the driving and to substitute a four wheel swivelling truck at front; in other words, to make a six wheel arrangement.

Many railroad men have been extremely doubtful about the success of a single pair of wheels operating on rails at speeds necessary for passenger service. It can be stated, however, that the greatest success has attended this operation and over a sufficient period of time to demonstrate there is nothing to be feared in the trailing of a single pair of wheels under a car of this sort. It is not recommended, of course, that cars be operated at high speed in reverse motion, but even so, it has not come to notice that any difficulty has been experienced in backing six wheel rail cars; the usual backing movements being under speeds of 25 miles per hour.

One point worthy of consideration is that in designing equipment of this sort, there should be used to as great an extent as possible, all the parts which the automotive manufacturers have developed under a quantity production basis and which are of minimum weight and maximum strength and durability. When a carrier purchases equipment, it is of great help to have available the stocks of parts which the auto truck manufacturers have available for quick delivery through their extensive service station organizations. Furthermore, the advantage of a stable organization back of the product which is being put into use is all important. It would be manifestly difficult for a carrier to continue the use of automotive vehicles, if, unfortunately, the vehicles were sold by a company which did not continue in business and would, therefore not continue to have its service available.

In further consideration of the six wheel arrangement, it may be stated authoritatively that there is no advantage in going to more wheels under a car which can be propelled by any of the existing automotive truck power plants. However, in order to secure acceptable riding qualities in the rear of a six wheel vehicle, it is desirable to have a wheel of a relatively large diameter; namely, 36 to 40 in. and arrangements to absorb shocks by rubber or other devices in connection with springs. Special consideration should be given to keeping the unsprung weight to the absolute minimum.

Operating Costs of 6-Wheel Rail Car.—Very casual investigation of the operation of six wheel rail cars shows low operating cost per mile. Cars built on 2 to 3 ton chassis operate on average rails with a gas consumption of 8 to 11 miles per gallon and cars built on 5 mi. chassis with gas consumption of from 4 to 6 miles. The gasoline consumption, of course, depends on atmospheric temperature, length of run, loading, grades and especially speed.

Maintenance should not exceed 5 cents per mile on the smaller car or 8 cents per mile on the larger one, over a period of time. Other operating costs depend on the local conditions, particularly as to wages. It may be assumed of course, that one man is required for the mechanical operation of the car but whether he can handle the collection of tickets and the performance of such other duties, depends altogether on local conditions and each railroad man can figure that out for himself.

The first cost of a car of the smaller type is usually around $9,000, and the larger car, around $16,000, depending on the refinements of construction of chassis and body, and particularly whether or not the body is built for severe or mild weather conditions.

So far as depreciation charges are concerned, that is a problem for each carrier to determine for itself. It seems reasonable to assume that vehicles of this sort can be perpetuated as long as it is desirable to maintain equipment of such type. Because of the rapid development ensuing in the design of gasoline driven equipment, it may be expected the final disposition of gasoline cars will be determined from the standpoint of obsolescence rather than actual physical depreciation, and this will be determined largely by the rate at which equipment manufacturers are able to develop something vastly better than is offered at present.

Cars of Larger Capacity Needed.—It is a relatively simple matter to develop the present six wheel cars, but when it comes to designing and building cars to meet from 50 to 75 per cent greater capacity requirements, one is confronted by a very different problem. This is unfortunate because although there is a considerable field for cars of the 6-wheel type, there is a very substantial and persistent demand for larger cars. Six wheel cars are built on the basis of 2 or 3-ton chassis, seating about 24 to 28 people, with a nominal baggage space, and cars on the 5-ton chassis seat about 35 people with a baggage space of approximately 50 sq. ft. There is great need for a car which will seat from 50 to 60 people and have a baggage space of about 100 sq. ft. and be able to make speeds of 40 to 45 miles per hour in either direction.

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*From a paper presented May 18 before the New York Railroad Club.

This larger requirement cannot be met by adaptation of any highway vehicle and requires starting practically with a clean sheet of paper to design a new outfit. It is necessary to go to a double four wheel truck arrangement because even if a power plant of sufficient capacity were available in a highway chassis, it would not be practicable to operate with a single non-swivelling axle except possibly on some very exceptional conditions of straight track. It appears that 25 ft. is about the practicable limit for distance between front truck center pin and rear axle center. In working out a larger design of car, if similar economies are to ensue, it is necessary to keep in mind the same characteristics of construction as prevail in the present automotive rail equipment and to keep the weight per horsepower to similar values.

Truck Manufacturers Logical Agencies for Development of Rail Car.—It is believed the large automotive truck manufacturers, with their staffs of highly trained engineers and their wonderfully equipped plants, are the logical agencies for the most successful development of the larger gasoline propelled rail cars. These manufacturers, however, appear lacking in confidence that there is a sufficient field of sale of such vehicles to warrant them in undertaking the expense of engineering development and additional shop equipment necessary to produce on the usual quantity basis. It is not, of course, to be anticipated that there will ever be sales of gasoline-propelled rail cars of few enough types to favor manufacture on a quantity production basis in any way approximating the procedure of the automotive industry today. It is to be hoped however, that the large automotive manufacturers will undertake the production of these larger units, on a modified quantity production basis; in other words, if these manufacturers could inject some flexibility into their organizations and their manufacturing appliances sufficient to meet this demand, it would appear, a highly satisfactory outcome could be expected.

Railroad men have a great variety of ideas as to the characteristics of equipment required to suit the local requirements of service and it is expecting, perhaps, too much to anticipate that railroad men can soon be brought to very close agreement on all of the points which would favor approximate quantity production. However, the automotive manufacturers could, unquestionably, develop such separate units as engines, clutches, transmissions, etc., on a quantity production basis and with sufficient flexibility as to the arrangements and connections between the several units to meet the varying ideas of the railroad fraternity in regard to what appear to be the desirabilities under the conditions of the individual carriers.

In this connection, it is necessary that railroad men make an earnest study of the engineering elements of this problem because by doing so, some will find it necessary to revise certain currently prevalent ideas and to operate in the direction of asking manufacturers to produce those things which can the more readily be produced for successful and economical operation. The development of larger lightly constructed, highly economical and efficient rail cars, may be retarded by the attitude of representatives of the carriers if they misunderstand the facts as to limitations of the power of gasoline engines, the relation between weight and power and the actnal desirability of the several types of wheel and truck arrangements, etc.

Gas-Electric Cars.—The gas-electric car is receiving consideration by engineers of two large electrical manufacturing companies in conjunction with car builders, gas engine builders and railway engineers, with the idea of obtaining lighter construction than in former designs. The gas-electric car has a number of advantages over the gas-mechanical drive, one of which is the ease by which double-end operation can be secured and by which power can be transmitted to any or all of the wheels of the car. However, because of the characteristics of gas-electric equipment, it is not possible to use as small an engine as with the mechanical drive.

Final figures from current studies are not available but preliminary values indicate that gas-electric equipment will weigh in the neighborhood of 25 to 50 per cent more per unit of carrying capacity than gas-mechanical. The input-output efficiency of the electric generator multiplied by the input-output efficiency motors, gives an overall transmission efficiency of about 75 per cent to 80 per cent for the gas-electric, this being the per cent of power delivered from the crank shaft to the rim of the wheels. In mechanical drive of the automotive type, the corresponding efficiency is about 85 per cent.

Furthermore, the combined weight of generator, motors aud control apparatus is greater than corresponding parts in a mechanical drive. The combined effect of lower transmission efficiency plus greater weight of machinery reacts on the size of gasoline motor, which reaction increases the weight of body and trucks. It will be surprising if a gas-electric car can be produced which will weigh as little per unit of carrying capacity as a gas-mechanical. Weight, however, is of prime importance in gas-engine design, cost, operation, maintenance, reliability and availability.

Those who have given most study and have had most experience with both the gas-electric and mechanical drive agree, at least on one point, that construction must be light if operation is to be satisfactory. Use of carefully designed parts, heat treated metals, avoidance of all unnecessary parts, reduction of friction in bearings, in truck parts and from atmospheric resistance is imperative. It is impossible in the space available to go into detail on many points but a few of the details may perhaps be considered profitably.

The continued operation of steam trains to handle 30 or 40 passengers and small amounts of baggage, mail and express, is wasteful and should be supplanted by more efficient equipment. Existing gasoline cars can handle the traffic offered on many light lines but occasional spurts requiring the seating of 60-75 people create a need for the larger car. In many cases, the change from expensive steam locomotive to cheap gasoline car operation, hinges on the production of the larger capacity self-propelled vehicle. The small gasoline cars built on modified highway chassis are exceedingly satisfactory to the extent of their capacity. Surely American engineers can increase that capacity 50 per cent to 75 per cent with corresponding efficiency, reliability and economy of operation. If the carriers and manufacturers get together properly, the problem can be solved and without either party hazarding funds of such extent that they are worth considering in view of the benefits possible.

Jobs Open for Valuation Engineers at $3,600 to $4,800

Washington, D. C., August 8, 1922.—The collection of the income tax becomes a complicated affair after it passes the point of figuring the return of the average wage earner. This part, of course, is simple.

The technical staff of the Bureau of Internal Revenue at Washington is in need of valuation engineers in general mining, coal mining, oil and gas, and the forest industry. The positions pay from $3,600 to $4,800 a year. The United States Civil Service Commission will receive applications until October 1. No written examination will be given; the ratings will be based upon education, training, experience, and physical ability.

The duties involve estimation of quantities, market values, value of equipment, cost of development, etc.

Full information and application blanks may be secured from the United States Civil Service Commission, Washington, D. C., or the civil service board at the post office or customhouse in any city.

Large Excavation Contract Let in Canada.—Contracts involving 1,659,000 cu. yd. rock excavation and 5,074,000 cu. yd. of earth excavation were let recently to Peter Lyall & Sons Construction Co., Montreal, Que. The work calls for the completion of sections 2 and 4 of the Welland Ship Canal. In addition to the above it includes watertight embankment, 446,000 cu. yd.; mass concrete, 1,300,000 cu. yd.; other concrete, 100,000 cu. yd.; steel bars for concrete reinforcement, 7,400,000 lb. The principal structures are—twin locks, 4, 5 and 6 in flight, single lock 7 and the guard gate, together with their entrance piers and other retaining walls, safety regulating and waste weirs, bridge structures, concrete bridges, two large syphon culverts and two docks.

Proposed Joint Freight Terminals for Chicago

One of the principal subjects selected by the Board of Economics and Engineering of the National Association of Owners of Railroad Securities, Inc., upon its organization in June, 1921, as warranting immediate study, was that of joint terminals. The increasing concentration of business in the great commercial centers has for a long period been evidence to the railroads of the approaching saturation of terminal capacities in their present form.

The terminals selected for study were those of the two principal cities, New York and Chicago. In addition to being the most important railroad centers in the United States, they are points where the terminal situation is at a most serious stage. New York, from its topographical position, offers problems peculiar to itself, and must be separately considered.

The board, which consists of F. A. Molitor, chairman, J. P. Hallihan, secretary, John F. Stevens, W. L. Darling, W. W. Colpitts, and Lewis B. Stillwell, has submitted its report on proposed joint terminals of Chicago. Extracts from the report follow:

Chicago may be taken as fairly representative of the situation found in inland terminals throughout the country, and the plans proposed for its improvement may be accepted, in a general way, as applicable elsewhere.

$1,000,000,000 Railroad Investment in Chicago.—To assist in visualizing the overshadowing importance of Chicago as a railroad center, it may be well to state that it is served by 23 separate carriers, operating 29 railroads into the city. Within the city limits are 16 independent belt or industrial lines, 80 or more points where freight is interchanged between roads, and 184 freight houses, 69 of which are in the business district. There are 120 freight yards and 65 locomotive terminals.

The area occupied for railroad purposes in the downtown section alone is 700 acres of a ground value of possibly 500 million dollars. Other railroad property and improvements lying within the terminal district represent an additional 500 millions of value, so that the total railroad investment in Chicago may be stated at approximately one billion dollars.

It is the purpose of the report to suggest plans and methods whereby the fundamental principles that should cover the operation of terminals in large cities can be applied so as to reduce the cost to the carriers of moving a revenue ton and improve the service to the shippers. In furtherance of this purpose a concrete case is submitted as an example of results that may be reasonably expected from co-ordination of effort and facilities in the public interest.

The intense efforts of individual railroads to obtain additional traffic in large cities, especially that requiring long haul, has resulted in increasing the cost per unit of service, delay to car movements, duplication of facilities, as well as requiring many interchange points, transfer and connecting railways.

The Fundamental Principles Governing Terminals.—The fundamental principles that should cover such terminals were best stated in the preliminary report, dated March 29, 1916, of the Chicago Terminal Commission, of which a former member of the board, the late John F. Wallace, was chairman, wherein it is recited that they shall:

"Enable the railroads to handle their passenger and freight traffic in what will be to them the most economic and the most efficient manner;

"Enable shippers to receive and deliver freight, and passengers to reach and depart from trains in what will be to them the cheapest, quickest, and most convenient manner;

"Enable the general public to conduct its business with the least practicable congestion of the city's streets and the least practicable interference with the expansion of existing business districts and the development of new areas of commerce and industry;

"Enable the city, as a whole, to recognize that above all it is a place where many human beings live and labor and to establish and work out these plans of physical development both residential and commercial—which will most effectively conduce to the prosperity, health and happiness of its individual inhabitants."

The application of these principles to any railroad terminal should result in a minimum of train miles and switching movements; delivery of passenger and freight at convenient points with a minimum of transfer service; an unobstructed road for through traffic; and a minimum of investment in properties and facilities.

Designs for terminal improvement along these general lines, after having been approved by the Interstate Commerce Commission, the city authorities and the railways interested, should govern all further capital expenditures or further changes in operating methods.

Chicago, on account of its intricate railway terminals, has been selected as an example of what can be accomplished by following these principles.

In Chicago the recommendations of the Chicago Terminal Commission, generally referred to as the "Wallace Plan," have been accepted by the board for the section of the downtown district to which they apply and as the basis for the extension of the same principles to the entire Chicago district.

For convenience the additions and consolidations suggested by the board are termed in this report the "Group Plan."

Chicago Terminal Improvements.—Summary of estimated cost of proposed improvements and savings resulting therefrom:

Estimated cost of rearrangement of freight facilities between State St. and proposed river channel, south of Polk St. to 16th, including change of Chicago River—as outlined and estimated in the Wallace Plan		$43,000,000
Estimated cost of changing methods of operating freight terminals by elimination of interchange points, transfers and connecting railways as per Group Plan proposed by Board of Economics and Engineering— $46,550,000—or say		47,000,000
Total		$90,000,000
Less—Value of ground space released as estimated by John F. Wallace	$60,000,000	
Value of Air Rights on property retained under Wallace Plan	25,000,000	
		$85,000,000
Estimated net cost of combined improvements		$ 5,000,000
Estimated net annual saving in operation cost and fixed charges under Group Plan alone ($16,155,259)		$16,000,000

The above estimates do not include the value of 24 hours' saving in time on all through and local business; the savings due to the use of three or four passenger terminals in place of six; savings in property by abandoning certain facilities and the reduction of future investment by reducing requirements for electrification, track elevation and other terminal expenditures.

One of the most important items of direct saving under the new plan is that due to the more efficient use of the power employed in the terminal. Probably not more than one-half, certainly not more than two-thirds of the capacity of the power now in use in the terminal districts is now utilized because of the frequency of long switching movements with short trains.

Under the new plan it would be the exception rather than the rule when locomotives were not utilized to full capacity. It is, however, impossible to estimate the value of the probable saving in this respect, because the records are not available to permit accurate deductions.

Description of Present Situation.—The freight traffic in and out of Chicago each day consists of about 27,000 cars.

Of these, 54 per cent, or about 14,600 cars, is through business; that is, freight merely passing through Chicago on its way to other points. The remainder, about 13,400 cars, less than half of the total, is local business; that is, freight of Chicago origin or destination.

The tracks required to handle this heavy volume of traffic constitute a network that has come to seriously interfere with commercial and industrial growth, to impede street traffic, and even to restrict the expansion of railway facilities.

While some of the trackage is operated in common by several roads, each line has its own yards and terminals, and receives and interchanges freight on an individual basis. A freight train arriving in Chicago goes to its individual yard. Here it may be broken up and distributed or it may be moved to another yard. The distribution may be directly to a freight house, to team tracks, or to industrial tracks. Delivery to whatever destination may be through a transfer road and about 50 per cent of the freight is so handled. The transfer may in turn distribute to another transfer and it in turn to the road to which the freight belongs.

At each of the transfer or delivery points there is a delay ranging from 13 to 18 hours. As a general average, the aggregate delay to business passing through Chicago, whether through or local, excluding train movements, is about 58 hours.

The local business handled through the freight houses and team tracks in the downtown district is in four principal divisions.

1. The Michigan Central and Illinois Central freight facilities on the lake front near Randolph St.
2. The facilities in the district east of Chicago river and south of Polk St. to 16th St. in which the Santa Fe, New York Central, Rock Island and several others are located.
3. The district bounded on the east by the Chicago river and west to Des Plaines St. between the Chicago river on the north and 16th St. on the south, covering the facilities of the Pennsylvania, Burlington, and Alton.
4. The district north of the Chicago river and east of Des Plaines St. in which the North Western and Milwaukee freight and team tracks are situated.

This comprises what is known as the downtown district. In addition there are a good many freight houses and team tracks scattered in outside areas for which at the preesnt time there are no large improvements needed.

Certain proposed plans are in contemplation for the rearrangement of facilities in District No. 1.

District No. 2 contains those facilities that are bound up with the proposed change in the Chicago river, for which ordinance has been passed and approved by the city. It is this district that is covered in the Wallace report where, by the expenditure of $43,000,000, there will be property released for business purposes between State St. and Clark St. and from Polk St. to 16th St.

District No. 3, comprising most of the roads using the Chicago Union Station, is now under construction, ordinances for which have been passed by the city.

District No. 4, comprising the North Western and Milwaukee facilities, have never been studied by the commissions.

The difficulties in the Chicago situation are greatly increased by the many interchange points and transfer and connecting railways. All improvements are made by individual roads without reference to co-ordination with other facilities.

Competitive methods increase the train miles necessary to handle the business, for when deliveries are made at interchange points, the road to which a car is destined must send an engine and crew to make the transfer to its own road, frequently requiring an all-day run to make the transfer of a single car. While this is an extreme case, nevertheless the number of light movements and the duplication of effort result in short trains and heavy train mileage.

Analysis of Present Conditions.—The principles on which the roads now operate are:

1. Individual competition with the temptation of adding unnecessary train mileage to obtain special business that is of temporary advantage to that particular road.
2. Interchanging at stated points of which there are at least 80 on and inside the Indiana Harbor Belt.
3. Transfer of CL and LCL cars from one road to another by means of transfer and connecting railroads.
4. Transfer of through LCL shipments through downtown freight houses and the city streets.
5. Capital expenditures made to suit individual roads without reference to co-ordination.

The total average business in and out of Chicago daily is:

	Cars.
Freight houses	4,580
Team tracks	1,636
Industries	6,027
Through business	14,488
Total	26,731

The report of the Chicago smoke abatement committee (H. G. Burt and W. F. M. Goss, chief engineers) states that in 1912 there were inside the city limits 9,212 different tracks with a total mileage of 2,731, of which 841 miles are elevated.

In the area bounded by the Indiana Harbor Belt Railroad and the cities of Gary and Evanston, there are 12,982 tracks with a total length of 4,389 miles, of which 871 miles are elevated.

Chicago receives and sends out 26,731 cars daily, with 6,600 left over and ready to go and approximately 13,000 cars on tracks loading and unloading (making a total of 45,600 cars some time during the 24 hours). Consequently there will be 45,600 cars at one time or another during a 24-hour day inside of the Indiana Harbor Belt and occupying 431 miles of track approximately, or 10 per cent of the total mileage.

When business is at its peak this occupancy is heavily increased causing congestion; at such times and even at all times slow train movements result, especially at the 80 interchange points and on the transfers which tend to increase the slow train movements.

Proposed Operation and Improvements.—The railway situation presents two problems:

1. Passenger service.
2. Freight service.

The passenger service is of two classes:

Through service (into and out of the city;
Suburban service.

It is not necessary to describe in detail the present passenger situation. Briefly, Chicago now has six passenger stations where both through and suburban trains are handled. It was proposed by the Chicago Railway Terminal Commission to consolidate them into three stations and an additional suburban station. These recommendations have been partly carried out as follows:

1. Northwestern Station—constructed and operated.
2. Union Station—under construction and now temporarily operated.
3. Illinois Central Station—ordinance for which has been passed but not yet carried out by the railroads.
4. Depressed suburban station at La Salle and Van Buren Sts.—under consideration.

This is probably the best solution for both through and suburban service that has as yet been offered.

An investigation is under way for a fourth station but plans are not yet available. In a general way its purpose is to create a fourth passenger station—designed so that air rights may be utilized—situated at Dearborn and Polk Sts. and occupying the property between State and Clark Sts., south of Polk St. There are really three questions involved in the use of this property.

Shall it be developed: (1) For business purposes only? (2) for fourth passenger station with air rights utilized for business purposes? (3) for additional freight facilities (possibly including the Illinois Central and Michigan Central freight business now on the lake front near Randolph St.) with air rights utilized?

The question is largely one of economics from the railroad and city viewpoints, and the release of property south of Polk St. between State and Clark Sts. from the city's point of view. The design of three stations for passenger traffic provides sufficient capacity to take care of present and future business.

Freight Service.—The service in Chicago is of two classes:

1. LCL (less than carload lots);
2. CL (carload lots).

LSL freight for Chicago and points beyond the city is delivered in cars loaded to an average of about seven tons each. Of the LCL cars going downtown approximately 600 cars containing over 4,000 tons are for out-of-town points. At present part of this is being transferred around the city but the greater part of it still goes through the city streets.

There are a present about 28,000 tons per day, or about 10,000,000 tons per ear of LCL freight coming in and going out of the city which costs the railroads:

	Per ton.
For operation	$1.77
For property value—Fixed charges	1.08
Total present cost	$2.85

The plan proposed contemplates a reduction of this figure as follows:

	Per ton
Reduction of fixed charges under Wallace Plan $40,000,000 at 6 per cent divided by 10,000,000 tons)	24 ct.
Reduction in operating cost under Group Plan	37 st.
Total reduction	61 ct.

Notwithstanding this substantial reduction, it will still cost $2.25 per ton to handle LCL freight into and out of Chicago.

No estimate has been made of the probable saving by consolidation of the city terminals, though a saving is no doubt possible.

Mr. E. H. Lee, vice-president, Chicago & Western Indiana, in an able analysis of the local freight-house situation (Am. Ry. Engineering Assn., 1914 and 1915) demonstrated that a very considerable saving could be effected by improvement in methods of operation and by the use of motor-drawn trucks.

Expansion of existing freight-house facilities with continuation of methods no win use serves only to increase the unit terminal cost, which at present absorbs a large percentage of the revenue from line haul. For xample, on LCL shipments yielding an average revenue of 2 cts. per ton-mile, these terminal costs are equivalent to a line haul of 112 miles on through business or a maximum of 224 miles on local business in and out of Chicago.

Proposed Improvements and Method of Operation.—The plan of the board is to divert all through business around the city. All cars into and out of Chicago are to be collected in group yards along the Elgin, Joliet & Eastern R. R., which is to be used as an outer belt. It is proposed to eliminate all interchange points of which theer are 80 shown in the Equipment Register; to eliminate transfer and connecting railways; to eliminate all freight yard and equipment facilities not needed for switching and passenger service. All through cars are to be transferred from group yard to group yard, and all improvements are to be made along this outer belt wherethey may be considered permanent until, aftr many years, the city's growth again requires a rearrangement.

It is proposed to use the Indiana Harbor Belt R. R. as a temporary belt line for transferring from the southeasterly group to the northerly group until it becomes necessary to devote it to other purposes on account of the growth of the city. There is no group yard provided at present north of Joliet for the reason that all existing railway yards are so located that they can be used conveniently. Eventually a group yard should be constructed at West Chicago, but no provision for it has been made in the estimate and all estimates of savings are based on the use of individual yards north of Aurora as at present except that the Illinois Central and the Chicago Great Western will use the Chicago & North Western yard at Proviso.

The group yards will be four in number, located at or in the neighborhood of Porter, Griffith, Chicago Heights and Joliet.

All freight terminals and service facilities except those required for the power employed in local switching service will be located in the group yards.

There will remain in the city only such freight terminals and service facilities as are required for business of Chicago origin and destination. All other freight will be by-passed around Chicago by means of the group yards and outer belt lines. In the group yards all freight interchanges between the roads will be made; all freight trains to and from city will terminate there.

Normally th emovement between group yards will be in full trains, and generally cars will be made up in full trains for the receiving road. So also will the city business leave a group yard in full trains for distribution after delivery to an industrial switching yard, and the makeup of trains leaving an industrial yard can readily be made so as to require the minimum of switching after delivery to group yard.

Construction of Group Yards at Porter—Capacity, 8,500 cars	$10,000,000
Construction of Group Yards at Griffith—Capacity, 10,300 cars	11,000,000
Construction of Group Yards at Chicago Heights—Capacity, 7,800 cars	9,000,000
Construction of Group Yards at Joliet—Capacity, 5,300 cars	6,000,000
Repair shop for heavy repairs—6,000 cars capacity	1,000,000
33 miles of second track E. J. & E. and Michigan Central at $55,000	1,650,000
New double track connections at Joliet (5) miles at $330,000	1,650,000
Improving Michigan Central 40 miles at $40,000	1,600,000
Various connections	1,500,000
15 miles new double track lines for connections at $210,000	3,150,000
Total	$46,550,000

Each group yard will have transfer platforms where all LCL cars may be consolidated for the city and for foreign lines. By this means about one-third of the LCL cars can be released in the group yard and the balance taken into the city in ordinary or specially designed cars in full trains.

Under present methods it often happens that ivndidiual roads do not bring in sufficient LCL freight to admit of proper consolidation whereas by grouping the lines, the aggregate LCL business of a group will always have a volume permitting advantageous consolidation.

A repair shop will be located at a convenient group yard to take care of heavy repairs for at least 6,000 cars per year.

It is recommended that a district be established along the Elgin, Joliet & Eastern in which there will be no industry, business or residence and that it be devoted entirely to railway facilities; travel across the district to be by established routes.

Under present methods the cost of operating the belt lines is increased because of the competitive methods used by the various roads in favoring shipprs with service that requires additional train miles. It is proposed to eliminate ths class of servce by group methods.

The constructive mileage necessary on some roads under this plan is largely overbalanced by the saving in train operation on other roads where terminals can be abandoned, short division runs operated as turn-arounds, and savings in mileage effected on other divisions that will be materially improved.

Approximately one-half of the city business, or 3,100 cars, goes to the freight houses and team tracks and the balance to industries. At present a large part of that traffic is transferred through the belt lines and the various break-up yards in the city.

Reasons for High Cost of Handling Freight and Proposed Economies.—The high cost of handling freight into and out of the city and for transfers beyond is due to:

(a) Fixed charges on large investments;

(b) Large number of interchange points;

(c) Transfers;

(d) Excessive train miles;

(e) Intricate switching service;

(f) Teaming of LCL business through city streets;

(g) Congestion during peak periods;

(h) Individual terminals and repair shops;

(i) Uneconomic use of power.

It is proposed to simplify these elements in order to effect economies thus:

(a) By reducing future expense for property investment and by disposal of some of the property now in use;

(b) Eliminating interchange points by making all interchange in group yards;

(c) Eliminating all through transfers inside of the city;

(d) and (e) Reducing train miles by better average train loading and more direct deliveries;

(f) Elimination of trucking LCL transfers through the streets by making these transfers direct in the group yards;

(g) Eliminating congestion by keeping half of the business out of the city; direct movements and simplified switching;

(h) By eliminating all freight terminals in the city except to care for the downtown switching and passenger locomotives by locating service facilities as well as the shops in the group yards and to consolidate passenger facilities at three points;

(i) Intensive use of power will naturally follow as a result of the foregoing changes.

The business now handled through all freight houses south of Polk St., between Clark and State Sts., does not exceed 17,000 tons or 2,150 cars daily.

It is proposed to make provision for a business of twice the existing volume, that is, for 34,000 tons or 4,300 cars daily, and for this volume a space of 8,600,000 sq. ft. is required. The entire space available includes the present occupied area and an extension of the same to the north of Polk St., comprising a total area of 5,940,000 sq. ft.

The plan of consolidating LCL freight at the group yards will reduce the number of cars coming into the city by one-third and consequently reduce the area required to 5,780,000 sq. ft.

It is evident, therefore, that the saturation limit of LCL facilites is not far distant and will soon be reached unless some plan of relief is put into effect at an early date.

Provision for 34,000 tons both in and out would probably be sufficient for the downtown district as the increase in business would be largely outside of the loop and served by outside freight houses and the existing industrial tracks; and the necessity for larger areas will be avoided by improved methods of handling LCL freight—as, for example, the use of containers.

The question of the consolidation of the freight business, as recommended by previous commissions, in the district between State St. and the straightened river south of Polk St., should be further investigated to determine whether it is not practicable to re-arrange the space now used by the various railroads for freight-house and team track facilities and thereby eliminate the necessity of freight yards on the lake front near Randolph St., avoiding the haul along the Lake front an dthrough the proposed passenger facilities on 12th St.

The question of eliminating all freight-houses and team tracks in the congested districts by locations outside has been studied by the Board, but without reaching a definite conclusion. The lowest price obtainable for container or other method of trucking is 25 cents per ton per mile which would mean $2.50 per ton if located ten miles out, and would exceed the fixed charges saved. This question is one which has not had, but should receive the full analysis it deserves.

It is proposed to consolidate all city CLC freight into cars carrying 11 tons each instead of 7 as at present; to use cars of special design in which heavy loadings are practicable and possibly flats to carry containers. The latter should be loaded, insofar as possible, for firms and individuals, in order to avoid re-handling through downtown freight-houses.

The question of containers for store door delivery is one that should have further study. If they are used from group yard to the city a greater saving may be effected.

Unified Control and Operation Necessary. The proposed plan can be made effective only through unified control and operation, but such control does not necessarily involve disturbance of existing ownership. Single administrative control is required and we believe may be secured by lease or operating agreement.

Considration must be given to the business advantages accruing to certain roads by reason of superior location and industrial connections, but these are of relatively little moment in comparison with the operating advantages to be gained under the proposed plan and can no doubt be readily adjusted in the common interest.

The improved operating methods indicated can be put into effect immediately upon the completion of the group yards, the proposed improvements along the Elgin, Joliet and Eastern and the addition of the required connections.

Cattle Guard Made of Old Boiler Tubes

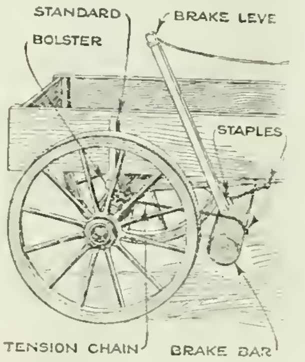
The natural trait of an animal to refuse to walk over anything that affords a non-rigid or precarious footing has been utilized by the Scioto Valley Traction Co., Columbus, O., in adopting a metal cattle guard of exceptional effectiveness. We are indebted to the Electric Railway Journal for the following description and illustration of the guard. Departing from the customary and rather inefficient spiked metal guard, or the wood type constructed of triangular cross-section strips, this guard is made of old boiler tubes, which are mounted so they will roll when stepped on. Though making the footing uncomfortable, the usual guard is rigid, so that its effectiveness is not all that could be desired.

The end caps of this unique guard, which hold the 2-in. boiler tubes, are made of malleable iron with seven $2\frac{1}{2}$-in. sockets, thus giving the tubes ½ in. of free play. The maximum distance that two tubes can become separated is about 2¼ in., a space which is insufficient to allow an animal's foot to become caught. It is the free rolling motion of each tube as an animal puts the first foot on it that brings into play its instinct to stay off.

The line drawing shows the exact dimensions of the malleable iron end castings, which are the only parts that have to be specially made. The only other work involved is the procuring and cutting to the right length of the old boiler tubes, which are available in large numbers almost anywhere. For protection they are given a coat of weatherproof paint. The installation of these metal guards involves only the spiking of the end caps to the ties. Since the guard is made in sections, for skew crossings each section can be displaced from the preceding one by the amount of the tie spacing. Another feature of this guard is that the length can be readily adjusted by merely cutting off the tube to the desired dimensions. At the sides of the guards, wire wing fences supported with iron posts are used. Maintenance of this type guard costs practically nothing and it is readily removable should the ties or rails need replacement. This metal cattle guard is the invention of Superintendent C. Skinner and it has been patented.

Mountain Type Wagon Brake

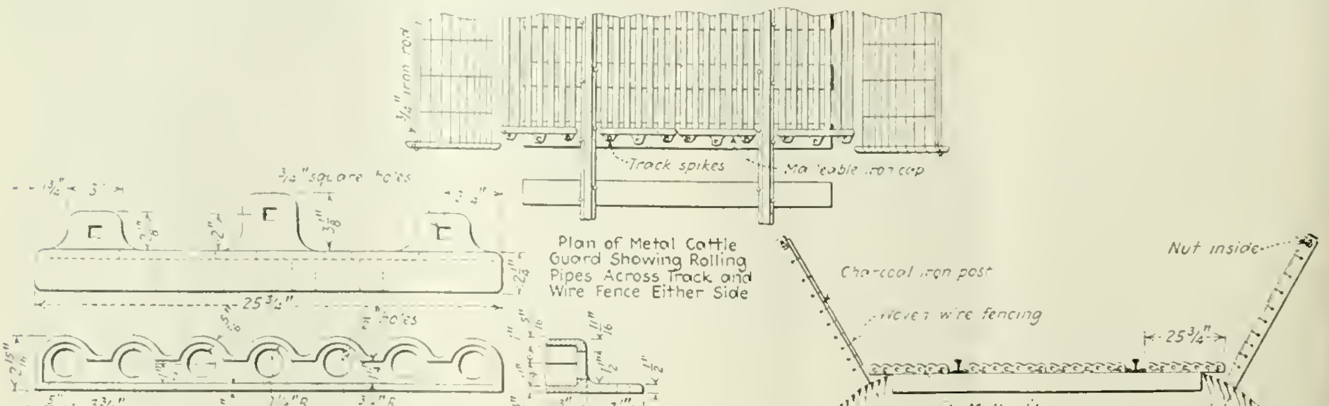
A form of wagon brake that might be of use to contractors working in mountaineous parts of the country, is described by Louis Schneider in a recent issue of Popular Mechanics. The brake produces a powerful pressure against the circumference of the wheels, and the speed of a wagon descending any grade which can be safely traveled is very nicely regulated.



A cylindrical brake bar is suspended, parallel with the axles, from the underside of the wagon gear by short chains, as in the drawing. The ends of the brake bar, which is made from part of the trunk of a small tree, should project 6 to 8 in. beyond the wheels on each side. A lever is inserted into the brake bar at one end so that the brake can be operated by the driver. When braking the vehicle, a forward pull on the lever brings the bar back against the wheels, and the amount of friction is controlled by the pressure exerted on the lever. When not in use, the brake hangs from the wagon gear out of contact with the wheels.

Safety Committees on the Chicago Elevated.—Each department of the Chicago Elevated Railroads has its own safety committee, which meets at regular intervals during regular working hours. Employes are invited to submit suggestions to the safety committee of their own department, and a very large number of such suggestions are adopted and put into effect. During the year 1921 977 safety suggestions were acted upon by the various committees, and 709 of them were approved.

A message from the railroad section foreman to the roadmaster read: "No 6 did not whistle. Send me a new handcar."



Details of Cattle Guard Used on 78 Miles of Interurban Line of Scioto Valley Traction Co.

Maintenance of Special Work

Practice of Eastern Massachusetts Street Railway Co., Described in Paper Presented at Track Maintenance School of the Company

By R. A. D'ARCY,
Division Engineer, Eastern Massachusetts Street Railway Co.

Special work is the most costly part of track construction; the part that requires the most attention and maintenance (but does not receive it); the part that gives the most trouble in operating and the part that has to be renewed first. Therefore, it is evident, when laying special work, that by using the best possible class of construction and properly maintaining all special work, money will be saved in the end not only because we will be able to obtain the greatest possible life from the most expensive part of track construction, but also the upkeep and depreciation of rolling stock will be materially reduced as, no doubt, a large amount of the wear and tear on the cars is due to bumping and pounding over broken and worn special work.

Proper Foundation Necessary.—The first thing that will be insisted upon hereafter will be a proper foundation under all new special work. The sub-grade must be rolled or thoroughly rammed and there must be at least 6 in. of crushed stone under the ties (and it is preferable that this also should be rolled).

The switches in [illegible] special work layouts are built with drain holes in the spring and heel boxes and also in the bed of the switch so that the water can escape and not prevent the proper operation of the switch by freezing. If means are not provided for the water to flow from these drain holes, their object is lost and more or less trouble sure to result. It is not sufficient to allow the water to run into the ballast, as in time this may affect the foundation.

With these two fundamentals, foundation and drainage, properly taken care of, the ties spaced so as to give good support to all castings and a support at least every 2 ft. under all rails and thoroughly tamped, the special work has a fair start, and it is safe to say that in 3 or 5 years it will not show loose joints, loose or broken arms or broken castings, as has so often been the case.

Maintenance of Switches.—Many reports come in of cars splitting switches. If the switches are given the required maintenance it should be an unusual occurrence for a car to split a switch. Most of the reports give for the cause, "a loose tongue." Now, every tongue of the late type switches is equipped with two tongue-tightening devices, one at the heel to hold the tongue back and down, the other a spring near the center. Both of these devices require a little tightening and attention from time to time, and if a reasonable amount of care is given them the possibilities of a split switch are reduced to a minimum.

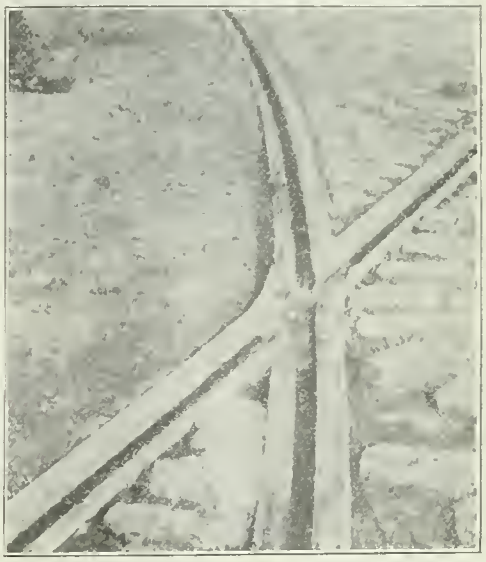
All the larger steel companies have adopted tongues with heels and heel-tightening devices which are very similar. Each company is furnishing a tongue with an enlarged heel area and most of them use a plain bar of spring steel set into the casting on one side of the pin, bearing against the pin at an angle and held on the other side by an adjustable bolt and nut placed in a box so as to be easily accessible for attention. The devices are simple and effective, but will become loose and useless if not oiled and adjusted occasionally.

The tongue-throwing springs have not been as varied as the heel devices, but each steel company has its own type. The plain springs are all simple and similar. The locking or two-way springs are of different designs and with but one exception have given satisfactory service and are easily maintained.

Inspect Spring Boxes Frequently.—It is evident that when a spring box becomes clogged with dirt or ice it will not function properly and there is a liability of breakage. Every spring box should be inspected periodically and the sand and dirt removed, the nuts tightened and the parts oiled. During the winter months much trouble has been experienced on account of ice in the box. A little experiment, tried during the past winter, has eliminated this trouble and helped in other ways. By packing the spring box with a heavy motor grease, all water and dirt has been kept out and the parts kept in good working condition. The grease did not freeze at any time and in no way interfered with the working of the spring.

Most of the divisions have assigned to one man the task of keeping all switches on the division in first-class shape. He is to keep all the big devices in good working condition, tight, oiled and free from dirt. He can make or have made any small part that breaks and will make and place shims at the pins on the old time switches when needed. He is made accountable for any loose switch tongues on his division.

On many of our T-rails, iron-bound frogs and mates with a 3 or 4 ft. arm extending beyond the hard center, the tie at the end of the arm has become loosened after a few years, allowing the arm to play and break away from the casting. In its present condition there is no appreciable jar on the cars, the piece is still in a safe condition and does not give any trouble. In a very short time the loose tie could be retamped (or renewed if necessary) and the arm tightened in the casting, and this piece would be good for years to come, none the worse for its misuse. Unfortunately, some of our foremen, because of the fact that the piece is not giving trouble, although it is plainly written on it that it is in distress, have let it "slide." Before long that arm is sure either to work entirely loose from the casting or to break off part of the casting. We then have a situation which calls for extensive and expensive repairs, and is very liable to be temporary at the best, with a resulting loss of years from the life of this frog.



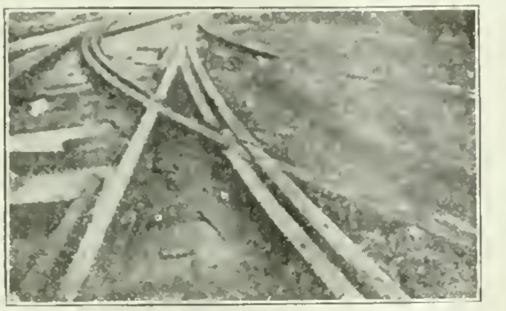
Home-made Frog in Carhouse Layout.

Loosened Spikes Cause Trouble.—We have on the system many solid manganese, short-length construction T-rail turnout ends. The curve from the switch extends some 8 or 10 ft. on to the lead rails. When many of these ends were installed, this curve was sprung into the leads with crowbars. In time the spikes become loosened and, naturally, this rail tended to straighten, making an angle at the end of the switch and mate. Before long the wheels would wear into the head of rail at this joint so as to spoil the mate. When this construction is used a permanent curve must be put into the lead rails with a machine. This also applies on any curve which can be sprung into line with bars to give a good looking job, but as soon as the spikes start to loosen, and they are sure to, the rail starts to resume its straight line.

The solid manganese, short-length construction T-rail special work has given very satisfactory service. All the steel companies have gone into manganese special work construction very extensively and naturally have been lauding its virtues. To my mind, from developments and experiences during the past few seasons, there are limits to the use of manganese and in some instances where it is used now extensively I believe special alloy forged or cast steel, because of the possibility to repair by welding, to be more suited for the purpose.

All the manufacturers are now furnishing manganese tongues in their switches. No doubt, because of its better wearing qualities, this is a distinct advantage, but the one grievous fault, the fact that a broken tongue cannot be satisfactorily repaired, offsets this advantage. If better provision against broken tongues could not be provided in future construction I would be much in favor of forged steel tongues.

Broken Manganese Tongues.—There is not a division on the system that has not been put to expense and difficulties because of a broken manganese switch tongue. During the past winter, when ice was forming fast, on more than one occasion there have been three broken tongues in one layout. Investigation has shown that practically all the breaks have been on the unreinforced type of tongue. Fortunately the new designs of the different steel companies call for reinforced tongues, so this may provide an additional guarantee against breaking. However, on a runoff switch under heavy traffic, where a pound is sure to develop at the heel, I recommend a special alloy or forged steel tongue which would give the advantage of repairing this pound in a satisfactory manner.


Two-way Home-made Frog in Ground Over 2 Years and Still in Good Condition.

The centers of all frogs received from the steel companies are made of manganese steel. Regardless of the kind of steel, a frog center is sure to pound or cup in time—the heavier the traffic the sooner the defect. Again, it is acknowledged that a manganese center will stand the wear longer, but once a manganese center pounds it cannot be satisfactorily repaired. By slowly and carefully surface-welding on manganese, quenching the steel with water often so as to keep the heat out of the piece, a center can be built up that may last months, or even as long as a year, but eventually the part built up and more or less of the adjacent steel will flake or break off, leaving a condition far worse than originally.

In the process of welding manganese, the properties of the steel are destroyed and no matter what kind of steel is used for welding, and what care taken in welding, the weld will not hold. Therefore, although a special alloy or forged steel center may not withstand initial wear as long as manganese (and this is questionable), satisfactory reclamation can be made when it is sure to be called for on forged steel, and it will eventually outlast a manganese center.

Dealing with Renewable Center Frogs.—We have many so-called rapid, renewable center frogs on the system with the centers held down by bolts and nuts of various types. Agani the theory did not work out in practice. It has been impossible to keep these bolts and nuts tight, and wherever this type of special work is in we have a noisy, troublesome layout. The men who have a layout of this type that they are unable to keep tight can do one of two things, either tighten the bolts and weld them securely in place or remove the bolts and babbitt the center in.

When babbitting a frog center or rebabbitting a shrunken-in center that has become loose, the work must be done thoroughly and properly to have the center hold. The center must be removed and the bed thoroughly cleaned, removing all dirt, old babbitt and any foreign matter. The bed should then be well heated and if it is felt necessary a coating of tin or bronze applied. In cold weather the center itself should be heated slightly. If the center is low, strips of steel can be placed under it to bring it to a good surface. The hot babbitt is then poured in with the necessary care in handling this explosive substance. It is a waste of time and very dangerous to try to babbitt a center without removing it from the bed.

Home-Made Special Work.—Every division on the system is now well equipped with welding and cutting torches, seam and surface welding machines, grinding machines, etc. With this equipment, there is little excuse for the divisions having any broken pieces of special work.

A T-rail frog is shown, made up at a very small cost, that has now been in the ground over two years and is still in excellent condition. The rails were cut and bent to the proper angle in the shop. A steel filler block from an old railroad crossing was cut up and used as filler blocks for the frog, various length machine bolts running through the frog fastened it together. By making the throat only 1¾ in. wide, the tread of the car wheel is riding on the frog point before it leaves the lead as shown in the picture—therefore, the point does not receive a blow but acts somewhat like a spring frog. A short guard was placed opposite the frog and in other cases a base plate placed under it.

In one car-house layout of 9-in. girder where relaying special work was used, three frogs were made up. The curved guard rail was laid in place. The guard and groove through the head and ends of the straight rails were cut with the torch to give the proper angle and the pieces fitted in place. Plates were then heated and bent so as to fit the angles. The plates were then seam welded to the rails and a true running surface and flange-bearing surface provided by the surface welder.

A very satisfactory compromise joint from a 9-in. girder to low T-rail was made up to replace a pair of broken plates. The head and part of the web of the girder rail was cut away for a foot in length so that the base of the T-rail could rest on the web of the girder rail and bring the heads to an even surface. A pair of 9-in. girder plates were then cut and bent to fit the two rails and all joints seam welded.

I do not mean to infer from the above that I would recommend that we go into the wholesale manufacture of special work, but mention these things to show what can be done in an emergency.

Precautions in Rebolting Special Work.—On the bolted T-rail special work, it is the exception if some of the bolts do not loosen after 4 or 5 years of service. Whenever rebolting a piece of special work, whether you are using the same or new bolts, it should be made the practice to use heat-treated bolts and two lock washers on every bolt. I do not claim that they will prevent the bolts from becoming loose again, but they will certainly take up much of the stretch and, if the special work is given the proper inspection from time to time, it will be noticed and tightened before it loses its grip. After the second tightening, when the permanent stretch has set in, I would recommend spot welding the bolts. This applies particularly to a railroad crossing, and I would further recommend that the steam road rails be spot welded to the steel base plate that runs the entire length of all our crossings. This will help to prevent the crossing from creeping and the spot welding can easily be cut away when it is necessary to renew a rail. If a rail is being replaced and the foreman feels certain that it is the last renewal that will be made, I would recommend welding the entire length of the rail.

Let me repeat: with a good foundation, proper drainage and periodic inspection and maintenance of our special work, we can save hundreds of dollars and have a better riding track with less noise, less wear and tear on the rolling stock and less derailments and split switches.

Conditions Abroad as Observed by an American Manufacturer of Construction Equipment

Mr. Henry Harnischfeger, President of the Pawling & Harnischfeger Co. of Milwaukee, Wis., has just returned from a six months tour around the world, in the course of which he visited Japan, China, the Philippine Islands, India, and several European countries.

The object of the trip was the investigation of business conditions and possibilities in the far East, particularly in Japan, China and India, where the Pawling & Harnischfeger Co. has branches.

Mr. Harnischfeger found these countries suffering from the effects of the world-wide business depression, since there is a large over-stock of materials of all kinds which must be used up before new supplies will be needed. Contrary to the general opinion there is a growing market in the far East for labor-saving machinery of all kinds. This is due to the fact that labor conditions are slowly reaching a point where costs of construction and manufacture are not very high. Furthermore, in spite of the fact that labor is cheap and so inefficient the labor costs on projects cannot be figured much lower than in this country.

There is considerable activity in the steel-making line and also in large civil engineering projects, such as power plants, drainage, irrigation and building construction.

Mr. Harnischfeger was particularly impressed with the opportunities in Burma for flood control. They have a problem with the flood disasters on the Irrawaddy River such as we have on our own Mississippi, and they are constantly building up embankments to keep the rivers within their channels. For this reason gasoline-driven excavating equipment will be needed over there. It will be necessary, however, on account of the intense heat, to design gas engines especially to withstand the high heats found in that country.

It is an interesting fact that particularly in the interior of India there is a large amount of construction work to be done but up to this time it has been particularly hazardous due to the loss of life among workmen, because of wild beasts and reptiles. It is believed that this work can be done very much more safely with the use of machinery.

The Indian people are very well disposed toward American-made goods. They feel that owing to the vastness of their own country and also of ours that we have had problems which are very similar to theirs and for this reason they believe that the machinery which Americans designed for the construction of the Erie Canal, Panama Canal, Mississippi flood control and other projects will meet their conditions. This experience which United States manufacturers have had has not been shared by European manufacturers since they have never had to contend with these propositions on such a large scale. There are only two great differences between the conditions in India and United States. First the different class of labor which they have in India and secondly in weather and climatic conditions.

Another feature which must be taken into account in the design of equipment for use in these countries is the fact that their bridge capacities and clearances are much less than ours and for this reason, for the present at least, mobile equipment must be built in such a manner that it can be easily dismantled.

Mr. Harnischfeger, while in Japan, visited the work being conducted by the Musashi Engineering Corp. on the Imperial Japanese Railroads.

Altogether Mr. Harnischfeger was much impressed by the possibilities of the far East and he believes that there is a good market there for labor-saving machinery of all kinds.

U. S. Civil Service Examinations

The United States Civil Service Commission announces open competitive examinations for the positions listed below on September 6, 1922, at any of the usual places at which examination is requested in applications received in time to mail examination papers. The examinations for junior assistant sanitary engineer and assistant sanitary engineer, which were scheduled to be held on August 9, 1922, are postponed to September 6, 1922. A vacancy in the Public Health Service, Memphis, Tenn., in the position of junior assistant sanitary engineer; a vacancy in the Public Health Service, Cincinnati, Ohio, in the position of technical assistant in sanitary engineering, and vacancies in the Public Health Service throughout the United States, at the salaries indicated below, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from these examinations, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion.

The salary for technical assistant in sanitary engineering is $1,500 to $1,800 a year; the salary of junior assistant sanitary engineer is $1,960 a year; the salaries of assistant sanitary engineers are $2,500, $2,800, $3,150, and $3,250 a year.

Appointees at annual compensation of $2,500 or less, whose services are satisfactory, may be allowed the increase granted by Congress of $20 a month.

Subjects.	Weights.
1. Theoretical and practical questions in sanitary engineering	50
2. Training and experience (rated upon competitors' sworn statements in their applications and upon corroborative evidence)	50
Total	100

Technical assistant in sanitary engineering.—Applicants must have a basic education fully equivalent to that represented by a certificate of graduation from a recognized standard high school or college preparatory school, plus:

(a) The full equivalent of at least two years of completed courses in a college or university of recognized standing, including the fundamental sciences (physics, chemistry and biology).

(b) The full equivalent of an additional two years of completed courses in a college or university of recognized standing, devoted to special training in the profession of sanitary engineering.

Note.—The usual four years' course leading to the degree of C. E., or the degree of B. S. in civil engineering, fulfills the requirements under both (a) and (b).

In default of such collegiate education, not less than four years of extra-collegiate study may be accepted as the equivalent of (a) and not less than four years of practical extra-collegiate training or experience in the profession of sanitary engineering may be accepted as the equivalent of (b).

Junior assistant sanitary engineer.—Applicants must have a basic education fully equivalent to that represented by a certificate of graduation from a recognized standard high school or college preparatory school, plus:

(a) The full equivalent of at least two years of completed courses in a college or university of recognized standing, including the fundamental sciences (physics, chemistry, and biology).

(b) The full equivalent of an additional two years of completed courses in a college or university of recognized standing, devoted to special training in the profession of sanitary engineering.

Note.—The usual four years' course leading to the degree of C. E., or the degree of B. S. in civil engineering, fulfills the requirements under both (a) and (b).

In default of such collegiate education, not less than four years of extra-collegiate study may be accepted as the equivalent of (a) and not less than four years of practical extra-collegiate training or experience in the profession of sanitary engineering may be accepted as the equivalent of (b).

(c) Not less than one full year (12 months) of postgraduate training or practical experience in the profession of sanitary engineering, such training or experience to have been acquired subsequent to fulfillment of requirements under (a) and (b).

For the vacancy at Memphis, Tenn., eligibles with experience in malarial control work are desired.

Assistant sanitary engineer.—Applicants must meet the requirements prescribed for junior assistant sanitary engineer, and have had two years' additional postgraduate training or practical experience in the profession of sanitary engineering.

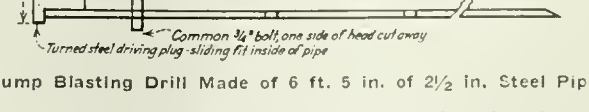
Further information will be furnished on request by the U. S. Civil Service Commission, Washington, D. C.

Stump Blasting Drill

BY VILAS H. JACKSON.

In blasting green stumps above 2 ft. diameter more time is spent boring holes through small roots, gravel, shale and clay to a depth which will bring the center of the dynamite under the center of resistance, than in loading, tamping and firing. A drill which has proved very useful in work of this kind is illustrated.

We drive the pipe home, remove plug, clean out core with a 2¼ inch auger, slide a scrap gear over the pipe, insert a ¾ in. bolt in most convenient hole and with one man on each side drive the pipe out in a moment leaving a clean, straight hole with firm, smooth sides, impossible with an augur in twice the time. We often cut 2 in. roots with the drill.


6'6"
1"
3"
3"
12"
12"
1"
3½"
Common ¾" bolt, one side of head cut away
Turned steel driving plug - sliding fit inside of pipe

Stump Blasting Drill Made of 6 ft. 5 in. of 2½ in. Steel Pipe.

A Quick Reference System of Filing Magazine Clippings

A useful method of filing clippings was described by Stephen L. Sinclair in The Journal of Electricity and Western Industry, from which we quote as follows:

For many years I collected clippings from technical and other magazines and papers but had difficulty in arranging them in a manner to permit instant reference to any clipping covering a subject to which a clipping might apply.

Like many others, I first tried pasting the clippings in a scrap book, which method proved unsatisfactory and inadequate due to the time required for filing and the necessity of a separate index, in addition to the fact that such a book is soon filled and becomes unwieldy.

I next tried filing in envelopes, and this was not satisfactory as too many envelopes are required if the clippings are to be thoroughly segregated for instant reference.

The method finally adopted requires the use of a standard filing cabinet, as illustrated, with drawers holding 6-in. by 9-in. index cards.

It will be noted that a page from a standard technical or similar magazine measures 9 in. by 12 in. and when trimmed and folded once will fit a 6-in. by 9-in. drawer.

A 6-in. by 9-in. index card is used for every subject and when a clipping covers more than one subject and does not permit of separation, in some cases the subject matter of each being on separate sides of the clipping, a properly titled separate card is filed to cover one of the articles on the clipping and on the card is marked the subject or index under which the clipping is filed.

For example, a clipping with reference to "Flow of steam through pipes" has on the reverse side an article relating to the "Melting point of fire brick." The clipping is filed under "Steam" and a separate card is filed under "Brick" and on the card is written "Fire Brick, Melting Point of"—filed under "Steam," see "Flow of steam through pipes."

In the case of small clippings they are pasted on 6-in. by 9-in. cards and are filed in the usual manner.

A cross index is used when necessary to list a single clipping requiring more than one key word.

In a six-drawer file I now have approximately 600 cards with subject matter. The last twenty odd cards in the file are indexed as follows:

Water, water hammer, water motors, water measurement, water treatment, water power, water wheels, waterproofing, weighing machinery, weights and measures, wells, welding, winches, wire, wire prices (this on a blue card), wiring tables, woodworking, vehicle equipment, zinc.

In magazines and papers there are innumerable articles that are read and forgotten which, if filed, in the above manner, are of great value for future reference. In such cases it is impossible to retain the entire magazine or paper on account of the large accumulation that would result and if retained in its entirety its usefulness is lost due to lack of an index, in most cases, which permits articles under any subject to be readily found.

To clip and file, in the above manner, articles of interest and value is not difficult and consumes comparatively little time providing it is done systematically and regularly. If a lot of clippings are allowed to accumulate without filing it then becomes burdensome. But having a place for immediate filing is in itself an incentive to do it now.

Overloading the Division Engineer

One of the most fruitful topics for discussion among maintenance of way officers is the maximum length of sub-division which should be assigned to a roadmaster or track supervisor. This question could be raised with equal appropriateness with reference to the proper length of the division engineer's territory. It is hard to reconcile the discrepancies in the lengths of territories or in the number of miles of line assigned to division engineers on different railways. Roads of more or less similar physical characteristics and traffic vary in their practices in this respect almost as widely as roads totally unlike. This may arise because of the fact that the present division limits are the heritage of organizations developed many years ago when there was a smaller mileage of tracks per mile of line and fewer other complicating factors.

In general the division engineer is in effect an assitant superintendent in charge of maintenance of way and as such his territory coincides with that of the division superintendent. A few months ago there was a distinct tendency, particularly among the western roads, to reduce the number of divisions by giving each superintendent more mileage. This in turn has added to the mileage of tracks under the supervision of the division engineer. In some cases his problem has been complicated still further by the fact that his jurisdiction has been extended to include two or more divisions.

The division engineer has to exercise detailed supervision to secure the best results. His forces are scattered in small units over the entire territory and do not come to a common point at any time in the regular course of their work. To exercise such supervision it is necessary for the supervisory maintenance of way officers to visit the gangs on the line frequently in order to insure that they are performing their work economically. It is impossible for the division engineer to do this over a long division of multiple track line handling heavy traffic. It is practicable, of course, to handle a greater mileage of single track lines with medium to light traffic than of busy multiple tracks and divisions of 300 miles or even more are not impracticable in most such cases. But a dense traffic multiple track division of 300 miles of line may aggregate as much as 800 miles or more of main tracks in addition to terminals. Such tracks must of necessity be maintained in condition to handle comparatively fast and dense traffic, and the forces required are increased accordingly. The magnitude of maintenance of way expenditures today is so great that it would seem desirable that the officers of the maintenance of way and operating departments study their organizations at frequent intervals in the light of the conditions which exist in order to keep them abreast of the developments of the road itself. It is not unlikely that such an investigation would develop the fact that there are divisions which should be lengthened—and others that should be shortened to secure the best results.—Editorial in Railway Age.

Personals

B. I. Spears has been appointed superintendent of the water plant of Ironwood, Mich.

Nelson A. Eckart, for many years on the staff of the city engineer of San Francisco, has been appointed a safety engineer for the city in the Hetch Hetchy project.

M. A. Gould, assistant engineer of the Illinois State Highway Department, has been appointed instructor in the civil engineering department of the School of Engineering of the University of Idaho.

Chester O. Wisler, assistant professor of civil engineering at the University of Michigan, has been appointed by the state conservation board to make a survey of water resources of Michigan.

Frank B. Newton, for several years county engineer of Jasper County, Missouri, has resigned to accept a position in the construction division of the Missouri State Highway Department. E. S. Glenn succeeds Mr. Newton as county engineer.

Ezra C. Shoecraft, for the past 9 years city engineer of Flint, Mich., has been associated with Hoad, Decker & Drury, consulting engineers, Ann Arbor, Mich. The name of the firm will be Hoad, Decker, Shoecraft and Drury, and the main office will continue to be in Ann Arbor.

Arthur Whitcraft, manager manganese steel sales, Hadfield-Penfield Steel Co., in addition to his previous duties, has been placed in charge of all foundry operations at the South Works at Bucyrus, Ohio. This extension of Mr. Whitcraft's duties was necessitated by the demands of an increasing production.

Frank A. Barbour and **G. Dale Dixon** have become associated under the name of Barbour & Dixon, with offices in the Tremont building, Boston, Mass., and the Finance building, Cleveland, Ohio. Mr. Dixon was late chief engineer of the Bureau of Water Works Improvement of Akron, Ohio. The firm will continue practice in Mr. Barbour's specialty of hydraulic work, including water supply, sewerage and disposal of sewage, flood control, etc.

J. Thompson Brown has been appointed general manager of the explosives department of E. I. du Pont de Nemours & Co., to succeed the late Charles A. Patterson. Mr. Brown was first employed by the du Pont Company in 1903 and has been engaged in plant engineering and special and general operating work at the high explosives plants. He has held the positions of secretary to assistant director, manager of dynamite works, general superintendent of the high explosives division, and finally assistant general manager of the department. He is a graduate of Virginia Polytechnic Institute and also took a course in engineering at Cornell University.

Industrial Notes

Brook, Smith & French, Inc., advertising agents of Detroit, Mich., have recently established themselves in new and improved quarters at John R. and Elliott streets.

The Florandin Equipment Co. has been organized by C. H. Florandin with offices at 110 West 40th street, New York City, to act as representatives of the Conveyors Corporation of America, 326 West Madison street, Chicago, manufacturers of the American steam jet ash conveyor and the American trolley carrier. The new organization will also do a general contracting business in and around boiler rooms and industrial plants located in New York City and its vicinity, erecting and installing the lines of equipment which the organization handles.

Building and Structural Monthly Issue

ENGINEERING AND CONTRACTING

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HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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E. & C. Index Furnished Only on Request

The index for Vol. LVII—January-June, 1922—issues of Engineering and Contracting will be ready for distribution shortly. In common with many other publishers we have adopted the practice of sending the index to only such subscribers as request it. Therefore, if you want the index for the last 6 months you should notify us at once. Those who requested the index for the previous volumes have been listed and need not notify us again.

Where Will the Rise in Prices Stop?

Apparently few people see the significance of the rise in average wholesale prices that has occurred during the last half year. For January the wholesale price index was 138, the lowest that it had been since October, 1916. For July it was 155, a rise of 17 points or 12 per cent in six months. Moreover, the rise has been accelerating. July was 3 per cent above June, and June was 5 per cent above April.

The peak of wholesale prices occurred in May, 1920, when the price index was 247, as compared with 100 for the year 1913. Probably not one business man in a thousand has expected ever again to see prices as high as they were two years ago. If asked to give reasons for expectancy of a price level lower even than the average for the last year, the typical answer is: "Prices always have receded steadily after a great war." But unless economic conditions following the recent World War are similar to those following previous wars, it is risky reasoning to argue that prices will decline steadily back to the pre-war level.

There is one great outstanding difference between the World War and every other war, namely the stupendous issue of paper money by all the leading nations of the world. In the case of our Civil War, our paper money was increased 230 per cent, but because most of our gold flowed away to Europe, the net result was that our per capita currency was only 30 per cent greater in 1867 than in 1860, and it did not change appreciably till 1876. Contrast that economic fact with the present fact. Our per capita currency is 45 per cent greater than in 1913, per capita gold is 80 per cent greater, and we have a new banking system that floods the country with paper money as rapidly as business expands. Moreover, all the leading nations of Europe have even greater capacity for issuing paper money than we have, under their present systems. Germany, for example, has so flooded its citizens with paper money that a gold dollar will exchange for 1,200 marks, as compared with 4 marks before the war. Austria and Russia are even worse examples of price inflation due to paper money inflation.

Yet, nearly all bankers continue gravely to tell us that the quantity of money has only a minor effect on wages and price levels! The head of our own Federal Reserve Banking system wrote to the editor not many months ago, in answer to a question, stating that it is high prices that cause increase in our money in circulation, and not increased money that causes high prices. But he failed to explain why increase in currency in Germany, for example, has always preceded a further rise in prices; and why the same phenomenon has occurred in every other European country that has increased its currency; and why price inflation has been greatest in those countries whose currency inflation has been greatest.

Currency inflation beyond the wildest dreams of "fiat money" advocates has occurred throughout the industrial world. Nothing remotely approximating this world-wide currency inflation is recorded in history. Prices have risen everywhere following currency inflation. Yet great bankers still tell us that credits rather than currency control price levels, or that increase in currency is an effect and not a cause of high prices.

It is true that as prices rise, bank credits expand and that this results in increased issues of federal reserve notes; but it is equally true that once those notes get into circulation they act to increase prices still more. This is an example of reciprocal cause-effect that is usually very confusing to men who have not studied science. The common belief is that a given class of energy is either a cause or an effect, and can not be both. But there are innumerable instances of reciprocal cause-effect. Take a simple illustration: A bellows may be used to start a fire. and fan it into a vigorous blaze. The breeze from the bellows is one of the causes of the fire; but once the fire is well under way the fire itself causes a breeze, or draft, that makes further use of the bellows unnecessary. In short, a breeze is one cause of a blaze, and the blaze then becomes a cause of a breeze. It is the same with our federal reserve money; higher prices produce more money, and more money produces still higher prices.

In addition to the fact that there is an unprecedented world-wide money and price inflation, we have another unique condition. America has 40 per cent of the total gold in the world, and gold continues to flow to America in vast volume because the leading nations are deeply indebted to America. Upon this vastly increased—and still increasing—base of gold, America will undoubtedly build a greater pyramid of bank credit and of paper money. Should there occur the business boom which most business men and bankers expect in the near future, federal reserve notes may fairly deluge the country. The gold reserve is now 80 per cent, and it will fall to 40 per cent before many warnings will be heard about gross inflation. The gold reserves of the Bank of England are less than 20 per cent, which gives an idea of how far inflation may safely go under a paper currency and credit system such as we have.

Banks, be it remembered, sell credit, and their annual profits increase proportionately with the amount of credit sold. Hence bankers are apt to be blinded by the prospect of enormous profits, and so continue to favor our present "elastic currency." The sole merit of its elasticity is that it can be used to discourage runs on banks. This is indeed a great merit; but, as at present managed, our "elastic currency" has a grave defect that will soon make itself evident again. As a result of the elasticity in our currency we shall witness another great inflation in prices and wages, an inflation that did not occur after the Civil War because our currency was not "elastic" then.

The editor looks to see average wholesale prices rise 30 per cent, and they may even go 50 per cent above the present level, or not far below the peak of 1920. We have all the money machinery with which to produce such an inflation, and we have more gold on which to base inflation than we had when the peak prices of 1920 occurred.

Structural Steel Not a Large Per Centage of All Steel or of All Building Materials

The Commercial and Financial Chronicle expresses surprise that there should be such great activity in building during 1921 at a time when the steel industry was at such a low ebb. It is not generally realized, even by men engaged in construction, what a small percentage of steel is used in construction.

The output of crude steel in 1919 was 34,671,232 gross tons; and the following were the outputs of the principal classes of finished product:

Rails	2,203,843
Wire rods	2,538,476
Structural shapes	2,614,036
Nails and spikes	606,700
Tin plate	1,150,898
Plates and sheets	7,372,814
Bars, etc.	10,359,543
Pipe and tubes	2,374,931
Total	29,221,241

The output of steel in 1921 was half that in 1919, but it will probably be shown later that the output of structural steel was more nearly normal.

We estimate that the cost of all the structural steel used annually is seldom more than 10 per cent of the cost of all the materials used in building construction. The tonnage of structural steel usually averages about 8 per cent of the total steel output. Such data explains why there can be very active construction at a time when the steel business is abnormally poor.

What Is "High Brow?"

A "high brow" is a thoughtful person whom you regard as knowing considerably more about a given subject than you do. The term "high brow," therefore, is purely relative. You are a "high brow" in the opinion of those who know less than you do about your specialty. In turn there are people whom regard as "high brow"—Einstein, for example.

We are led to make these remarks by the fact that occasionally we are told that Engineering and Contracting is "too high brow for me." Doubtless this is true as relates to some subscribers. Indeed it could not be otherwise in an engineering and contracting periodical, for most of its readers are necessarily "high brows" with respect to a few of its readers. A construction superintendent, for example, subscribes with the object of training himself to become a contractor. He sees an article on construction accounting that contains terms that he does not understand. To him that article is the production of a "high brow," although to nearly every other reader it is not.

There are relatively few articles in Engineering and Contracting that can not be read with understanding by any man who is at all ambitious to master a given subject. A beginner in any field must make up his mind at the start to find words and expressions that are obscure to him. Let him continue his reading in that field, and, even though he does not look up a single word in a dictionary, he will soon learn the meaning of most words merely by the context or association with other words. This, in fact, is the way that children acquire a vocabularly. A child does not despair because he encounters new words daily, but he blunders along, unabashed by his ignorance, undaunted by his mistakes. An adult, on the contrary, is apt to have a false pride that makes him ashamed of his inability to grasp at once the sense of a word or expression. And if he lets that pride dominate him, he will always remain a "low brow" in every subject, unexpert in everything.

Finding the Right Engineer for the Place

The American Association of Engineers is about to undertake one of the most significant investigations that has to do with engineering training and employment. An analysis is to be made of engineering positions to determine just what qualifications are required, what qualifications the engineer should be expected to obtain in early training, and what he should have gained in practical experience. The practical value of this work is evident. It will help put the right man in the right place. The Association has appointed a committee, and as chairman of this committee has selected A. B. McDaniel of Washington, D. C., who has made an enviable record in the classification of industrial positions. The committee is assured of the hearty cooperation of Dr. C. R. Mann, who prepared the report on engineering education for the Carnegie Foundation and who has given so much attention to the requirements of engineering training and of the government departments employing large numbers of engineers. The results of this investigation cannot be other than of the utmost value to those in charge of engineering education as well as to organizations requiring the services of large numbers of engineers.

The Mechanical Working of Invar.—Invar steel is very difficult to work mechanically but is an important alloy for certain classes of work where very low coefficient of expansion is desired. In order to see whether it could not be worked successfully, 4 small ingots of invar were prepared by the Metallurgical Division of the U. S. Bureau of Standards. The first attempt at forging was unsuccessful, the ingot cracking and breaking under the forging press. The second attempt was quite satisfactory as a result of very careful handling during forging operations. It was found necessary to give very light reductions and not allow the forging temperature to drop below 1,000° C. during the first reduction. This ingot was forged to a ⅜ in. rod, and a portion of this was cut off and machined to a ¼ in. rod. This has been cold drawn with 2 intermediate annealings down to approximately 1/16 in. wire. It is being carried further with the idea of determining how fine a wire of invar may be made.

Special Form Work for Black Street Bridge, Hamilton, O.

The Black St. bridge at Hamilton, O., a 7-span reinforced concrete arch structure, 654 ft. between abutments, was completed last March by the Miami Conservancy District. An interesting feature of the work was a special construction of the arch forms. We are indebted to the July Miami Conservancy Bulletin for the following details:

A substantial saving in the amount of lumber used was secured at Black Street by the use of a semi-removable falsework. First, a skeleton structure was built up on the pile foundation, as shown in Fig. 2. Five bents of 11 posts each were used under each arch. These bents were placed on pile footings. At the level of the top of the piers a deck of longitudinal timbers was built, which helped brace the bents, and which also took the first thrust from the batter posts. A cap for each bent was run across the deck, both to carry the wedges for the vertical posts above, and to act as a heel for the batter posts. Then came the wedges, (to facilitate bringing the forms to the right level, and to make dismantling easy), then another cap, and then the eleven 8x8 vertical posts on each bent. This skeleton was thoroughly sway-braced. On top of the vertical posts was placed a strip of lagging, with bolts projecting upward that were gripped by the concrete after it was placed. This frame work composed the part of the falsework that remained in place throughout the work, and that carried the dead load until completion. It also afforded support for the forms for the spandrel walls and cantilever sidewalk. Full details are shown in Fig. 1.

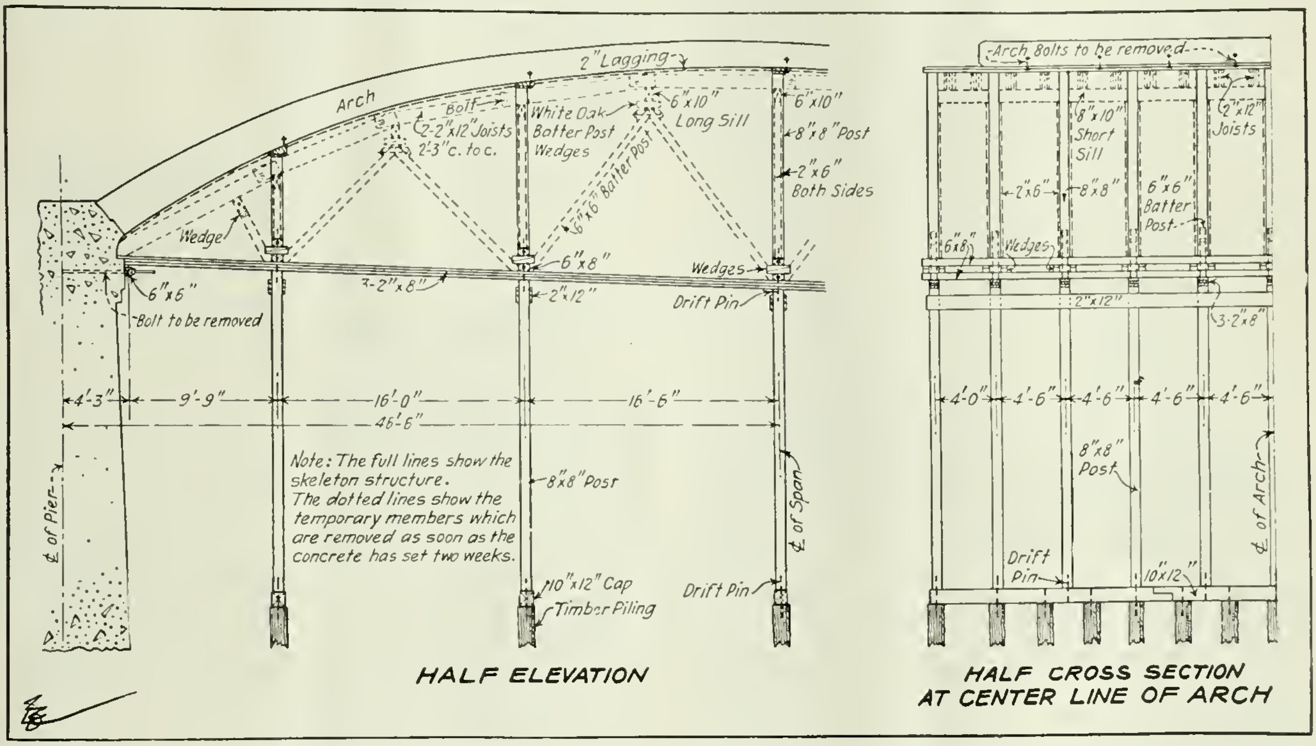

Fig. 1.—Sketch of Arch Forms. The Sway Bracing Has Been Omitted on the Drawing. The Stringers In Some Cases Were Cut from a Single Piece; in Others the Curved Part Was Spiked to a Straight Stringer. Not All the Wedges Were Oak; Some Were Good Quality Pine.

Further falsework was necessary to hold the lagging supporting the green concrete. A 2 in. by 6 in. strip of lumber was bolted to the side of each vertical post above the deck. Short caps went on top of the 2x6 strips, between the vertical posts, and these in turn carried the stringers supporting the lagging. The batter posts were independent of the vertical posts, and were supplied with wedges just beneath the cap. The stringers and lagging were cut and laid as the ordinary form work for structures of this kind.

After the arch ring had been poured, and the concrete had set, all the lagging except the strip on top of the vertical posts, the stringers, the batter posts, and the 2x6 strips, were removed, leaving the arch supported by the skeleton falsework. This was done by taking out the bolts fastening the 2x6 strips to the vertical posts, and springing them out of plumb, and by loosening the wedges at the tops of the batter posts. With the pressure off of the lagging, it was easily removed. As the posts of the falsework had been carrying all of the load, in the first place, no additional load was placed upon them when the lagging was removed, and no settlement occurred. All of the lumber which was removed was used over again. But three sets of lagging, stringers, batter posts and strips were used for the entire bridge, instead of a full set for all seven spans. The forms as built required some special mill work, but the economy in lumber was so considerable that the net saving was about $4,000. The plan was a complete success in every way.

Unusual care was taken in cutting the forms. Bolts were used as fastenings wherever possible. To insure accurate construction of the arch forms, the curves were laid out on a nearby tennis court. A framework was built of light lumber and laid down on the curves so located. Using stakes set at the centers, and proper radii, curves were marked on this framework, and the templates thus outlined were sawed out and used to mark the joists and side forms for the arches. Settlement allowances were made 0.04 ft. at the center of the arch, and 0.08 ft. midway between the center and the piers. The extraordinary care used in cutting out was reflected by the excellent fit secured, and the lack of alternations at the last minute.

Reference to Fig. 2 will give the spacing and size of the reinforcing. The extra bars under the street car tracks should be noted. In placing the steel, care was used in spacing accurately, and lacing bars 3.8 in. steel pass above and below the transverse bars, forming a lattice work, and steel and concrete spacers were used to preserve the spacing.

Concreting Operation.—The same general methods were used throughout the construction of the bridge. Each arch was poured in three longitudinal rings of equal width, the middle one first, then the outside ones. Each ring was poured in one run. A hopper was set in the center of each arch, with a spout going in each direction down the slope of the arch. The batches were run alternately in both directions, so as to balance the loading on the forms. Back forms were used for a distance of 25 ft. to 30 ft. from the piers. To prevent rising of these top forms from the pressure of the semi-liquid concrete, ¾ in. rods were used to tie them down. The concrete mix in the arches was six bags of cement per cubic yard of concrete, which is nearly 1:2:4. The maximum size of the gravel used could be passed through a 3-in. circular opening. Steel stubs and keys were placed in the arch concrete to connect with the reinforcement for the spandrel walls and counterforts.

Features of the Spandrel Walls.—The outstanding features of the spandrel walls are the use of counterforts, and the

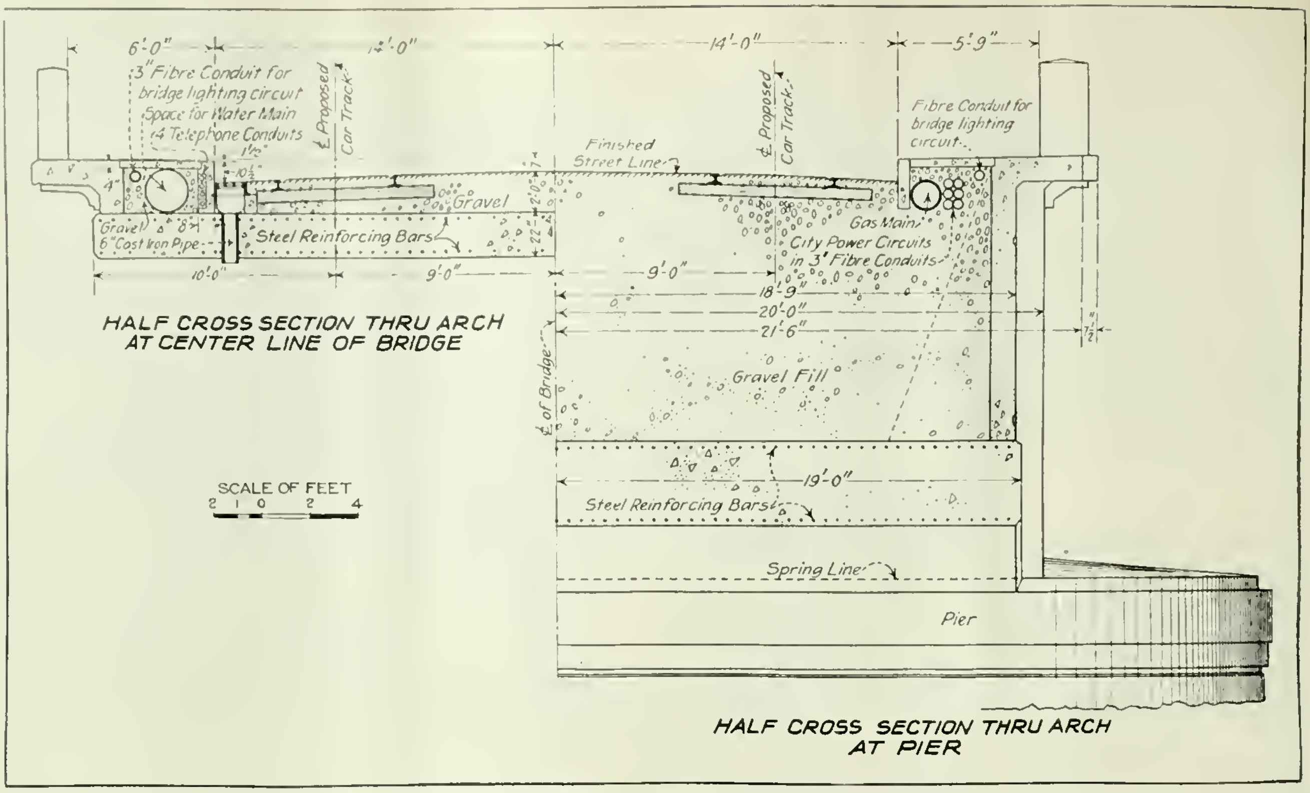

Fig. 2.—Drawing Showing Details and Dimensions of Black St. Bridge. The Tracks Shown Will Not Be Placed at Present. Extra Steel in the Arch Is Provided to Carry Extra Load of a Street Car.

use of five expansion joints. The expansion joints split a counterfort into two parts, and extend directly through the spandrel walls, dividing each into four sections. The outside forms for the walls were built first, then the steel was placed and then the inside forms were set. The sections were poured alternately, and each section was run continuously from the arch to the top of the sidewalk. The walls were finished with 1 in. of mortar colored with lamp black in the proportion of 2 lb. of lamp black to a barrel of cement. Only the outside half of the sidewalk is a part of the spandrel wall. The inside half of the sidewalk will not be laid until the bridge is paved.

The reason for this form of construction was to provide a place for conduits for public service lines underneath the sidewalk at the outside of the bridge. Otherwise it would have been less expensive to build the entire sidewalk as a cantilever project. The concrete aggregates used in this part of the work were washed and screened. The coarse aggregate passed through 1½ in. circular openings, and the sand through 3-16 in. by ¾ in. slots. Slightly more than seven bags of cement per cubic yard of concrete were used, the mix being from 1:1½:3 to 1:2:4. The expansion joints were filled with ½ in. layer of asphalt and felt compound.

The pilasters over the piers were poured after the spandrel walls had been completed, and were separated from the latter by expansion joints. Fiber conduits were placed in the top of the pilaster, with the lighting circuit.

The posts for the railing were poured in place first, and

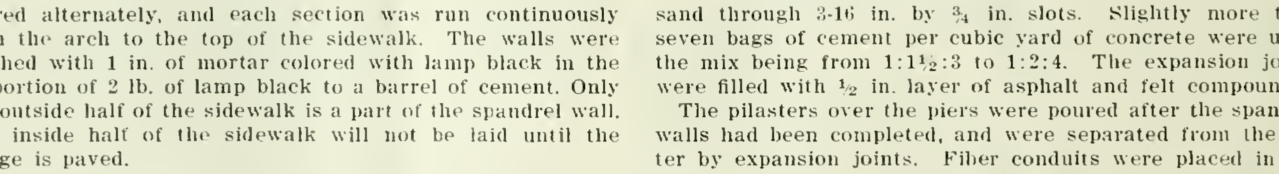

Fig. 3.—View of Black St. Bridge, Hamilton, O., Under Construction by the Miami Conservancy District, Dayton, O.

The arches are in various stages of completion. The one in the foreground has the full set of forms for the arch and spandrel walls in place. On the next two the forms are only partly in place. On the fourth and fifth only the skeleton frame work supporting the completed arch remains in place. On the last arch visible, the work is so far along that the posts for the railing are set. The wires overhead and the tower in the background are a part of the cable way used to transport materials and to handle forms.

after the forms had been removed the sections of rail were built between the posts. The railing is solid, in contrast to the various types of opening railings in vogue in this vicinity. The scupper holes at the bottom are for the purpose of providing air circulation as a preventive of the usual dust and trash nuisance. Eight bags of cement per cubic yard of concrete were used, the mix being 1:1½:3. The tops of posts and railings were finished with a steel trowel, no mortar being used. Steel templates were used to get a true line for the ridges on top of the railing.

Water Proofing.—Water proofing was applied to the tops of all arches, tops of piers, and to counterforts and to the backs of the spandrel walls below the top of the sidewalk. It consisted of a bituminous oil priming coat and three coats of asphalt applied in alternation with two layers of impregnated cotton fabric. Weep holes are provided at the low points, the asphalt membrane carrying water to them. This work could only proceed in good weather, great care being necessary to insure a tight job. One month was required to water proof the entire bridge.

As soon as the water proofing was completed, the space over each pier and abutment was filled to a depth of 2 ft. with oversize stone from the screening plant, to provide free drainage. This stone was carefully placed by hand around the drain pipes. Then, with 4 yd. dump cars running over a 36 in. gage track, gravel and sand from the channel excavation was brought in to complete the filling.

The New Equipment Rental Agreement of the Associated General Contractors

The executive board of the Associated General Contractors of America has adopted an equipment rental agreement, as a standard form for distribution to the membership of the Association. Its object is to establish on a basis of common equity those obligations and responsibilities properly involved in renting construction machines, and to provide a simplified rental agreement which will insure absolute fairness to both parties.

The form adopted is the result of investigations and criticism of members of the Associated General Contractors extending over a period of two years. It was prepared under the direction of the Committee on Methods, of which A. P. Greensfelder, Secretary of the Fruin-Colnon Contracting Co., St. Louis, was Chairman, and Ward P. Christie, Research Engineer. Through use of this form it is believed that many difficulties incident to renting construction equipment can be eliminated.

Both construction and equipment leasing companies have frequently been subjected to expense and annoyance on account of misunderstandings which arise when equipment is rented by verbal or letter agreement or by an unsuitable form of lease, and it is to overcome such difficulties as these, as well as to eliminate drastic and unreasonable provisions, that the new standard form has been adopted. Misunderstandings frequently arise from the fact that equipment is sometimes rented on short notice when the need arises, and when the main consideration is to get the machine into operation. In such instances, a telephone call, a letter or almost any kind of a lease, may serve to close a transaction, and when the unexpected happens both parties find that the responsibilities are not properly defined or that one or the other is saddled with an unfair obligation.

Situations of this nature can usually be avoided where the construction company has a suitable form of lease, easily filled out and familiar to its officials and executives. When all companies are using the same form the chance of misunderstanding is even more remote, especially when arrangements for leasing must be hurriedly made by letter or wire.

The standard form is arranged so that all blank spaces for filling in of dates, rental rates and other stipulations are segregated on the front of a single sheet, and those provisions of general application and requiring no filling in for ordinary conditions are segregated on the back. Thus a concise form of letter size convenient for filing is afforded.

Copies may be obtained from the Associated General Contractors of America, 1038 Munsey Bldg., Washington, D. C., or through the secretaries of associated organizations, at 10 ct. each or $5 per hundred.

Locomotive Loadings for Railway Bridges*

By D. B. STEINMAN.

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Abstract of a paper in the May proceedings of the American Society of Civil Engineers:

The object of this paper is to direct attention to the inadequacy of the Cooper system to represent properly modern railway loadings; to submit, for the consideration of the Engineering Profession, three alternative forms of a new loading system based on the stress-producing effects of modern locomotives; and to secure, through discussion, a consensus of opinion as to which of the three proposed forms should be recommended as a future loading specification.

Why New Loading Seems Desirable.—The Cooper system of loading was introduced into American bridge practice about 30 years ago. At that time, the heaviest loads to be provided for were properly represented by Cooper's E-40 loading, consisting of two consolidation locomotives with 40,000 lb. on each driver axle, followed by a uniform train load of 4,000 lb. per lin. ft.

AXLE—LOAD DIAGRAMS (FOR 1 TRACK)

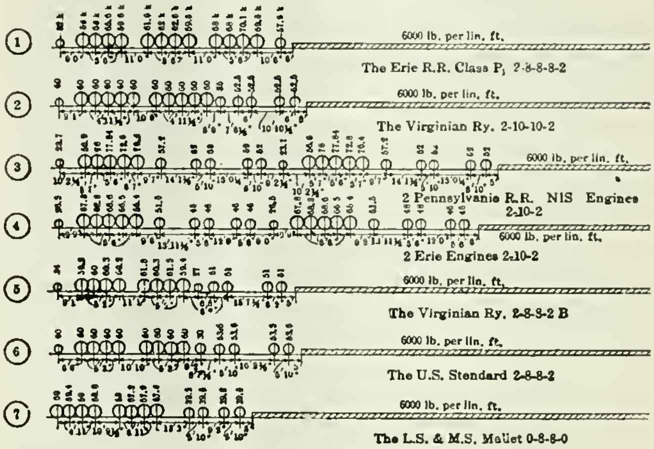
①
6000 lb. per lin. ft.
The Erie R.R. Class P1 2-8-8-8-2
②
6000 lb. per lin. ft.
The Virginian Ry. 2-10-10-2
③
6000 lb. per lin. ft.
2 Pennsylvania R.R. N1S Engines 2-10-2
④
6000 lb. per lin. ft.
2 Erie Engines 2-10-2
⑤
6000 lb. per lin. ft.
The Virginian Ry. 2-8-8-2 B
⑥
6000 lb. per lin. ft.
The U.S. Standard 2-8-8-2
⑦
6000 lb. per lin. ft.
The L.S. & M.S. Mallet 0-8-8-0

Fig. 1.

Since then there has been a rapid and continuous augmentation of locomotive and train weights. To provide for this increase, the original Cooper's E-40 loading was raised in successive specifications to the present values of E-60 and E-70 by applying fixed multiplying factors to the original loading diagram. This procedure could be applied indefinitely, without error, if the governing locomotive types and wheel spacings remained unchanged, and if the uniform train loads increased in the same proportion as the axle concentrations.

However, the old consolidation locomotive has been superseded by new types of engines having different wheel groupings and weight distributions. The wheel diagrams of such modern locomotive types as the Mikado, Mallet, or Santa Fe, bear little resemblance to Cooper's engine diagram. Moreover, since the days of the E-40 loading, the axle concentrations have increased 100 per cent, whereas the weight of train per linear foot has increased barely 50 per cent. It should be obvious, from these considerations, that a limit has been reached in the proportionate stretching of the old Cooper engine loading to make it fit modern loading conditions, and that the time has come to make a fresh start, with a system based on the existing locomotive and train loads.

Besides minor anomalies, the most serious indictment against the Cooper system is that bridges of uniform strength for present-day traffic cannot be obtained except by specifying different classes of the Cooper loading for different lengths of span and for different members of the same span. The maximum equivalent Cooper rating of the heaviest existing locomotives varies from E-75 for short spans to E-60 for long spans.

The Cooper loading does not correspond to modern locomotives, and its retention as a standard for design is unscientific. Its use produces designs that are unbalanced for present-day loadings. For instance, the Pennsylvania Railroad N1S locomotives are equivalent to Cooper's E-55 for some bridge members and to E-75 for others, a range of variation of 37 per cent. The Erie 2-10-2 locomotives are equivalent to Cooper's E-53 for some bridge members and to E-70 for others, a range of variation of 32 per cent. Other locomotives, compared by the writer, gave similar ranges of variation. In other words, structures designed for the arbitrary Cooper loading will not be of uniform strength for a given modern locomotive; some of the members in a span will be defective in strength in comparison with others, and some of the spans in a line will be disproportionately weak in comparison with others; and this difference in strength may amount to as much as 30 or 40 per cent.

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*Abstract of a paper in the May Proceedings of the American Society of Civil Engineers.

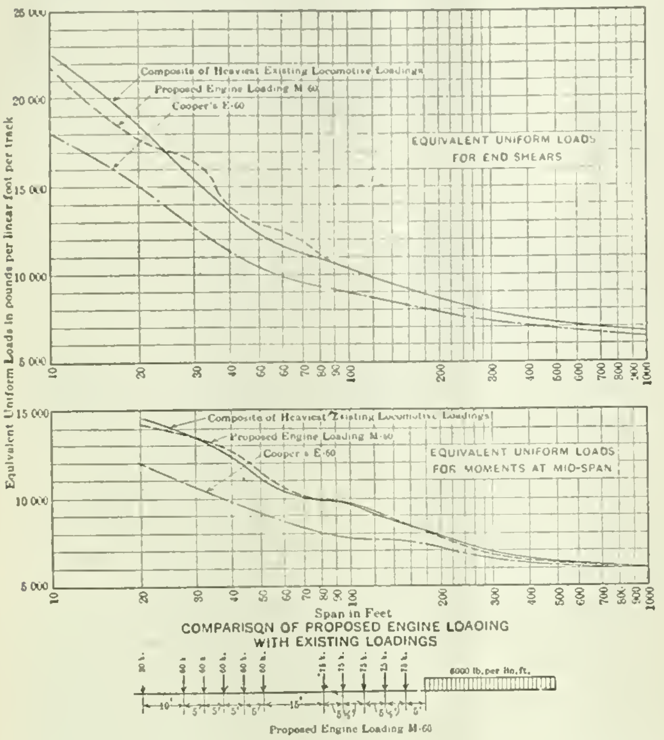


Fig. 2.

An argument advanced for retaining the Cooper loading is that it affords a convenient standard for rating bridges; but the writer maintains that a standard that has become warped to such an extent as to yield results that fail to harmonize by 30 to 40 per cent, has outlived its usefulness.

Requirements of New Loading.—A new loading, in the form of a diagram, formula, or chart, should be developed for future specifications. This loading should satisfy the following requirements:

1.—It should give results that harmonize closely with the stresses producible by modern heavy locomotives.

2.—It should be heavy enough to provide for the probable future increase in loading during the desired life of the structure. Accordingly, it should be from 25 to 50 per cent heavier than the average present loading (supposed to be represented by E-60).

3.—It should be presented in such form as will yield maximum facility of application and will discourage meaningless refinement of computation.

The foregoing considerations have prompted and guided the investigations embodied in this paper.

Composite of Heaviest Existing Locomotives.—The first step toward establishing a new standard loading was to make an analysis of the stress-producing effects of the heaviest existing locomotives.

Accordingly, the writer determined the equivalent uniform loads for the seven heaviest existing locomotives. The locomotives included in this analysis and comparison are the following:

(1) The Erie Railroad Class P1 (2-8-8-8-2).
(2) The Virginian Railway (2-10-10-2).
(3) Two Pennsylvania Railroad N1S engines 2-10-2).
(4) Two Erie engines (2-10-2).
(5) The Virginian Railway (2-8-8-2).
(6) The U. S. Standard (2-8-8-2) B.
(7) The Lake Shore Michigan Southern Mallet (0-8-8-0).

In order to present in graphic form the composite stress-producing characteristics of the heaviest locomotives, the maximum values of the equivalent uniform loads were next platted on a chart. This chart does not represent any single known engine but, instead, it represents a maximum composite of all existing engines and train loads, including the heaviest types. No known loading can produce a greater stress in any member than is given by this chart. Surely this fact alone ought to commend the chart as a standard for future loading specifications.

Having constructed, as a substitute for the Cooper system, a composite of the heaviest existing locomotives in the form of a table and a chart of maximum equivalent uniform loads, the problem of devising a more condensed and more tangible form of representing this new loading system will be discussed. In the following pages, the writer presents three alternative solutions of this problem:

1.—A proposed engine diagram, consisting of a simple conventional system of axle concentrations, followed by a uniform train load.

2.—A simplified loading diagram, consisting of a uniform load with a floating group of three excess concentrations.

3.—A loading formula, giving directly the equivalent uniform load for maximum stress at any section of any span.

These three alternative methods of specifying the proposed loading system will be presented and discussed in turn.

Proposed Engine Loading.—The engine loading diagram devised to represent the composite of the heaviest existing locomotives is shown on Figs. 2 and 3.

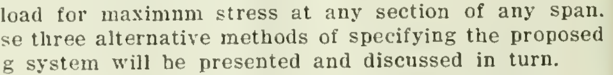
Of necessity, a locomotive of the Mallet type was adopted. (Five of the seven heaviest locomotives, as shown on Fig. 1 are of the Mallet type.)

Five axles to each group of drivers were found to be necessary. (Three of the four heaviest locomotives have Decapod grouping.)

This makes a total of ten driving axles, the same as in the heaviest locomotive loadings Nos. 2, 3 and 4. (In Nos. 5, 6, and 7, there are only eight driving axles. In No. 1, there are twelve driving axles).

In order to obtain the same stresses for small spans as are produced by the heavy group of driver concentrations of Locomotive No. 3 (Pennsylvania Railroad N1S), it was found necessary to make one group of axle loads in the proposed engine diagram, 75,000 lb. each. The axle loads in the other group were made 60,000 lb. each, in order to keep down the stresses for longer spans to the values produced by Locomotives Nos. 1 and 2.

PROPOSED ENGINE LOADING SYSTEM
FOR DESIGN OF RAILWAY BRIDGES



Loads per Track

M-10 = 5	10	10	10	10	10	12.5	12.5	12.5	12.5	12.5	1000 lb. per lin. ft.
M-40 = 20	40	40	40	40	40	50	50	50	50	50	4000
M-50 = 25	50	50	50	50	50	62.5	62.5	62.5	62.5	62.5	5000
M-60 = 30	60	60	60	60	60	75	75	75	75	75	6000
M-70 = 35	70	70	70	70	70	87.5	87.5	87.5	87.5	87.5	7000
M-80 = 40	80	80	80	80	80	100	100	100	100	100	8000
M-90 = 45	90	90	90	90	90	112.5	112.5	112.5	112.5	112.5	9000

Loading M-60 will give stresses for all spans very close to the maximum stresses producible by the heaviest existing locomotive loadings. It is approximately equivalent to Cooper's E-75 for short spans and to Cooper's E-60 for long spans

Fig. 3.

The spacing of the 60,000-lb. axles was made 5 ft., as this is the closest spacing of such axles in any existing loading. The spacing of the 75,000-lb. axles was made 5½ ft., for the same reason. (In Locomotives Nos. 2, 5, 6, and 7, the 60,000-lb. axles are spaced approximately 5 ft. apart; and in Locomotives Nos. 1, 3, and 4, the heavier axles are spaced 5½ ft. apart.) The heavier group of axles was placed in the rear, following the precedent of Locomotive No. 1.

A pair of pilot wheels was added, as required by the stresses, in accordance with the precedent fixed by the six heaviest locomotives. The trailing wheels and tender, however, are considered as being absorbed in the uniform train load which follows the locomotive. As modern cars have concentrated loads exceeding those of the trailing wheels and tender, it is inconsistent refinement to represent the one by concentrations and the other by a uniform load.

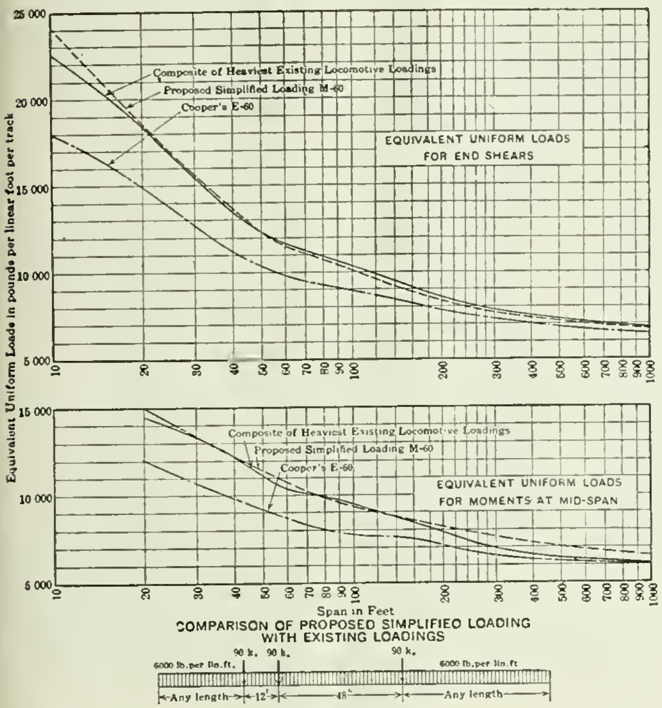
The proposed engine diagram is thus reduced to a conventional 2-10-10 grouping of wheels, followed by a uniform train load of 6,000 lb. per lin. ft.

In Fig. 2 there is presented, in familiar form, a graphic comparison between the different loadings under consideration namely:

(1) Cooper's E-60 loading;

(2) The composite of the heaviest existing locomotives; and

(3) The proposed engine loading (M-60).



COMPARISON OF PROPOSED SIMPLIFIED LOADING WITH EXISTING LOADINGS

Fig. 4.

The stress-producing effects of these loadings are represented by graphs of equivalent uniform loads for end shears and center moments for spans of varying length.

For both shears and moments, the Composite Standard is about 25 per cent heavier than Cooper's E-60 at short spans and gradually approaches coincidence with the latter at very long spans. If Cooper's E-75 is substituted, it will cause an excess of 25 per cent at long spans.

For end shears, there is the slight discrepancy of a few per cent., previously mentioned, between the Composite Standard and the proposed engine loading (M-60) at short spans. Except for spans of less than 24 ft., the variation is on the side of safety. For spans of more than 90 ft., the two curves coincide, indicating that the proposed engine loading is the exact equivalent of the Composite Standard in this range.

In the graphs for center moments, there is a remarkable agreement between the proposed engine loading (M-60) and the Composite Standard. The two curves follow each other throughout, with maximum variations of only 1 or 2 per cent except for one point having a difference of 2.9 per cent.

This agreement between the two curves is as close as could reasonably be demanded. Closed agreement cannot be secured without sacrificing the simplicity and uniformity of the proposed wheel-load diagram. The variation is so small that the proposed engine loading (M-60) may safely be accepted as a close equivalent of the composite of the heaviest existing locomotives.

The tabulation in Fig. 3 shows how the proposed engine loading can be diminished or augmented in fixed ratios to form different classes, in the same manner as the Cooper system of engines.

After conference with other engineers, the writer has decided to designate the proposed engine loading, previously derived, as equivalent to the heaviest modern locomotives, by the class symbol, M-60. The letter, M, stands for "Modern", "Motive Power", or Mallet". The class number is made 60 to symbolize, in the conventional manner, the weights of the first group of driver axles and the weight of the uniform train load. An additional reason for the designation, 60, was to simplify the conversion to different classes.

For spans up to 100 ft. the proposed Loading M-50 is about equivalent to Cooper's E-60. This is shown by Table 3 which gives the equivalent Cooper ratings of the proposed Loading M-50 for spans from 10 to 1,000 ft.

It will be observed, from Table I that the Cooper equivalent of M-50 diminishes from E-54 as short spans to E-50 at very long spans.

A reverse rating or conversion table is presented in Table II which gives the M-ratings of Cooper's E-60 loading for various spans.

According to Table II, the M equivalent of Cooper's E-60 ranges between M-47 at short spans and M-60 at long spans; but it is fairly well represented by M-50 for all spans below 100 ft.

Proposed Simplified Loading.—As an alternative for the proposed engine diagram to represent the composite of the heaviest existing locomotives, the writer has devised an equivalent simplified loading which has certain advantages and may be preferred by some engineers.

This proposed simplified loading (Fig 4), consists of a continuous uniform load of 6,000 lb. per lin. ft., on which is superimposed a floating group of excess concentrations. These concentrations, determined after a number of trials, consist of three 90,000-lb. loads spaced 12 ft. and 48 ft. apart, respectively.

The use of a simplified loading of this form greatly facilitates the computation of maximum stresses. Any stress is calculated by simply considering the uniform load and then adding the independent contribution of the group of concentrations. The latter contribution is quickly found; there are only three concentrations and they are easily placed and

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TABLE I—EQUIVALENT COOPER RATINGS OF THE PROPOSED ENGINE LOADING (M-50).

Spans.	E-rating for center moments.	E-rating for end shears.
10	E-60	E-60
20	E-59	E-59
30	E-62	E-62
40	E-64	E-61
50	E-63	E-62
60	E-61	E-63
70	E-61	E-62
80	E-61	E-60
90	E-62	E-58
100	E-62	E-57
120	E-60	E-57
140	E-58	E-56
160	E-56	E-56
180	E-55	E-55
200	E-54	E-55
250	E-53	E-54
300	E-52	E-54
400	E-51	E-53
500	E-51	E-52
600	E-50	E-52
700	E-50	E-52
800	E-50	E-52
900	E-50	E-52
1,000	E-50	E-51

TABLE II—EQUIVALENT M-RATINGS OF COOPER'S E-60 LOADING.

Spans.	M-rating for center moments.	M-rating for end shears.
10	M-50	M-50
20	M-51	M-51
30	M-49	M-48
40	M-47	M-49
50	M-48	M-49
60	M-49	M-48
70	M-49	M-48
80	M-49	M-50
90	M-48	M-52
100	M-48	M-52
120	M-50	M-53
140	M-52	M-54
160	M-53	M-54
180	M-54	M-54
200	M-55	M-55
250	M-57	M-56
300	M-58	M-56
400	M-59	M-57
500	M-59	M-57
600	M-60	M-57
700	M-60	M-58
800	M-60	M-58
900	M-60	M-58
1,000	M-60	M-59

easily calculated. For stringer and floor-beam spans, only the first two concentrations enter.

To provide for different loading classes, similar to the different classes in the Cooper system, the proposed simplified loading can also be expressed in multiples of a smaller unit loading.

Proposed Loading Formula.—As a third alternative solution of the problem of representing the composite of the heaviest locomotives in more condensed form, the writer offers a loading formula which gives directly the equivalent uniform load at any section of any span.

In the opinion of other engineers besides the writer, this is an ideal solution of the problem, as a formula possesses many advantages over an engine diagram:

1. It yields results of singular smoothness and regularity, unattainable with any diagram of wheel concentrations. The minor irregularities in stress variation due to unavoidable peculiarities in any concrete engine diagram are eliminated.

2.—It is a time saver, as it yields maximum stresses directly without the labor of shifting a wheel-load diagram and calculating the contributions of individual concentrations.

3.—It facilitates the construction of tables, stress, diagrams, and charts, and yields diagrams of greater simplicity, smoothness, and accuracy.

4.—It is more easily remembered than a wheel-load diagram, and saves repeated reference to the specifications.

5.—It makes the designer independent of reference books, as the ordinary slide-rule takes the place of all tables, diagrams, and charts.

6.—It is more flexible than a wheel-load diagram, being more easily modified to adjust it to any desired change in variation of equivalent loads with length of span.

7.—It is more scientific than an arbitrary loading diagram.

The formula devised by the writer to represent the maximum equivalent uniform loads of the heaviest existing engines is as follows:

$$q = 5{,}000 + 60{,}000 \frac{\sqrt{l_2}}{l + l_2} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

in which

l = the shorter segment of the influence triangle for any stress;

l_2 = the longer segment of the influence triangle; and

q = the corresponding equivalent uniform load for maximum stress.

Empirical formulas for equivalent uniform loads have been proposed in recent years, but they were deficient in one respect, namely, they expressed the equivalent uniform load as a function merely of the span without regard to the position of the member or section in the span.

The proposed formula, notwithstanding its simplicity, makes full provision for the necessary variation of equivalent uniform load for different sections or members in the same span. For instance, in the case of a 100-ft. span, the proposed loading formula yields values of q varying from 9,240 for bending moments or flange stresses at mid-span, to 11,000 for flange stresses near the ends of the span; and from 11,000 for end shears to 13,480 for shears near mid-span; a total range of variation of 46 per cent. This variation corresponds to the actual stress-producing effects of locomotive loadings, and the reproduction of this appropriate variation of equivalent uniform loads within a given span is an important advantage of the proposed loading formula.

The possibility of fairly close representation of the equivalent uniform loads for all sections of all spans by a single formula is a point of superiority of the proposed Composite Standard over the Cooper engine loading.

Conclusion.—After showing the inadequacy of the Cooper system to represent modern loading conditions properly, the writer has constructed a Composite Standard covering the strett-producing effects of the heaviest existing locomotives and has then devised three alternative forms of specification conforming to this Composite Standard.

The advantages over the Cooper system of any loading specification based on the Composite Standard are:

1.—The proposed specification makes it possible to design bridges strong enough in all their parts, without waste, for the heaviest existing locomotive loadings, without requiring separate computations for each loading.

2.—The proposed specification gives bridges of uniform strength in all their parts for present and prospective future loadings, without requiring different load ratings for different members in a span.

3.—The proposed specification gives designs of uniform strength for bridges of all spans under present and prospective future loadings, without requiring different load ratings for different lengths of span.

4.—The proposed specification, being based on the heaviest modern locomotives and train loads, better represents the future development to be expected in loadings than a specification based on the engines and train loads of thirty years ago.

In addition, the proposed specification, in the three forms presented by the writer, offers advantages over the Cooper loading in simplicity, regularity, ease of computation, and greater facility of diagrammatic representation.

Of the three alternative forms developed in this paper for the proposed new specification, each has distinctive features to recommend it:

1.—The proposed loading diagram represents the smallest departure from present methods, involving merely the substitution of a new and simpler wheel-load diagram for the one now in use. It will best meet the requirements of engineers who prefer a concrete picture of a locomotive as a loading specification. Furthermore, it affords the closest agreement throughout the entire range of spans with the composite of the heaviest existing locomotives.

2.—The proposed simplified loading greatly reduces the time and labor of calculating stresses. It is a greatly simplified loading which can be handled expeditiously without tables or charts.

3.—The proposed loading formula is an ideal, scientific form of loading specification. It is the most convenient in application; it yields tables, diagrams, and charts of unequalled simplicity and regularity; or, if tables and charts are not at hand, any maximum stress can be found by a simple operation on the ordinary slide-rule. It is a "short-cut" specification, virtually prescribing stresses rather than loads.

Can Building Construction Be Made Less Seasonal

David Lupton's Sons Company, recently sent a questionnaire to architects, engineers and large manufacturers in the eastern half of the United States, to disclose whether the main obstacle to winter building is its higher cost, and if so whether it would be feasible to stimulate it by winter reductions in prices of materials and in wages and profits.

Replies indicate that on small work, such as residences, the cost of rearing the wall construction would be impracticable. Where the climate is not too sever, work can be carried on between cold waves. This puts the immediate loss on the men, who must make up the idle time by higher wage scales on days they work.

On large construction projects work can be carried on by using tarpaulins and heating appliances, at from 3 to 10 per cent extra cost. At present, this differential is paid usually by the owner, due to his need for early completion. Sometimes part is absorbed by the contractor through competition; sometimes, part by labor on account of competition for work; sometimes part by the materialmen, through desire to maintain production in the slack season. Opinions of large contractors indicate that this form of winter construction could be stimulated by a general practice among all parties interested to reduce winter prices enough to make winter construction attractive.

Regarding industrial buildings, a difficulty arises because expansions are authorized by a corporation usually at its January annual meeting. If no preliminary plans have been made, it is likely to be May or June before the contractor gets started. This situation could be helped, if intending builders would prepare plans the previous fall, so that only revision and refiguring would be required after the January meeting, thereby enabling an immediate start by the contractor.

David Lupton's Sons Co. intend to carry their investigation further, as the advantages of uniform manufacturing conditions for material producers, and of uniform employment in the building trades, are so great as to deserve an earnest effort to bring them about.—Editorial in The Contract Record.

Factors of Design for Warehouse Facilities*

A study has been made of 15 warehouses, general data on which are given in Table I.

In order to profit by the experience secured in the operation of these warehouses, the operating officials were requested to suggest any alterations which in their judgment would make a more satisfactory relation between the various facilities. This then permitted not only a comparison of the actual facilities, but in several cases also the comparison of factors which the experience of the operating officials showed were desirable.

Elevators.—The question of amount of warehouse space per elevator is one which does not admit of a definite solution and a very great variation might, therefore, be expected. The principal reasons for this variation are the size of warehouse, the number of tenants involved and the wide difference in the length of turnover of goods, size and speed of elevators. As an indication of the prevailing practice as to the size of elevators, the information contained in the Table II is presented.

TABLE I.—GENERAL DATA ON WAREHOUSES INVESTIGATED.

Reference No. of warehouse (Note A).	Date of construction.	No. of floors.	AREA OF FLOOR SPACE, SQUARE FEET. (Gross—No deductions made for columns, elevators, etc.)			No. of of freight elevators.	No. of R. R. cars serving each house.	Tailboard frontage, lin. ft.	Remarks.
			Shipping platform (Note B).	Storage space served by elevators (Note C).	Total storage space (Note D).				
1	2	3	4	5	6	7	8	9	10
1	1918	8	44,800	3,894,000	3,894,000	72	93	1,824	U. S. Army (E).
2	1918	8	37,670	1,344,000	1,573,500	24	90	960	U. S. Army (E).
3	1918	6	19,800	512,000	565,500	7	28	90	U. S. Army (E).
4	1918	6	(Note F)	600,000	600,000	10	F	101	Over L. C. L. freight house.
5	1917	3	20,860	561,100	561,100	15	32	F	Over L. C. L. freight house.
6	1917	7	(Note F)	357,100	357,100	7	F	F	Railroad warehouse.
7	1917	8	12,110	282,100	282,100	7	20	216	Privately operated.
8	1915	4	22,700	438,300	438,300	6	24	356	Used by one tenant.
9	1914	8	(Note F)	184,400	184,400	6	F	F	Railroad warehouse.
10	1912	6	(Note F)	96,600	96,600	4	F	F	Railroad warehouse.
11	1911	8	7,370	201,800	223,900	4	8	100	Privately operated.
12	1910	8	6,840	230,400	256,300	4	9	100	Privately operated.
13	(Note G)	6	50,400	1,261,400	1,421,000	30	100	1,000	Privately operated.
14	1907	5	(Note F)	145,100	145,100	8	F	633	Over L. C. L. freight house.
15	1901	4	5,950	185,700	221,600	5	11	100	Used by one tenant.

Wherever floor area is used in this report gross area is considered, no deduction having been made in any case for columns, walls, elevators, checkers' booths, scales, aisles, etc.

Note A—The same reference number will be used to designate warehouses throughout all tables in this report.

Note B—The shipping platform space shown in Column 4 is the platform space adjacent to car siding used for shipping purposes.

Note C—The storage space shown in Column 5 does not include shipping platform space shown in Column 4, but does include all other space served by elevators.

Note D—The total storage space shown in Column 6 includes all warehouse space except shipping platform space shown in Column 4.

Note E—The U. S. Army Warehouses Nos. 1 and 2 are located on seaboard, and are served by both boat and rail.

Note F—Facilities of Warehouses Nos. 4, 5, 6, 9, 10 and 14 are used by both freight house and warehouse and, therefore, exact amount used by warehouse is not obtainable.

Note G—The first section of Warehouse No. 13 was constructed in 1905, the second in 1908, and the third in 1920.

In order to reduce the many sizes of elevators to a uniform basis, they are listed according to their capacity in number of 3 ft. by 6 ft. trucks, which seems to be the size in use in the majority of the warehouses. The warehouses are placed in order of dates of construction. By referring to Table II, it is evident that the tendency in modern warehouse construction is to install larger elevators. The more recent installations have elevators with a capacity of four trucks, which requires an elevator platform approximately 9 ft. by 17 ft. It is also evident that the capacity of elevators in pounds has been increased in proportion to their size. There has also been a tendency to increase the speed, but as an increase in speed very materially increases the most of elevators the progress in this direction has not been as rapid as in the size and capacity. The number of floors traveled also functions in determining the proper speed, but as most warehouses do not exceed eight floors in height, the question of speed is not as vital as in some other classes of buildings. In arriving at a suggested area of warehouse floor space per elevator, it is assumed that elevators will be installed of a size sufficient for four trucks, with a corresponding capacity and speed as dictated by modern warehouse practice, which seems to be a capacity of 10,000 lb. per elevator and a speed of 150 ft. per minute. This assumption is also justified by the development in freight house construction, as practically all of the recent elevator installations in freight houses have been of this size elevator.

TABLE II.—INFORMATION ON ELEVATORS.

No. of warehouse.	Date of construction.	No. of elevators classified as to capacity in 3'x6' trucks.				Speed in ft. per min.	Capacity in lb.	Remarks.
		1 truck.	2 trucks.	3 trucks.	4 trucks.			
1*	1918	...	...	...	72	150	10,000	Satisfactory.
2	1918	...	...	...	24	150	10,000	Satisfactory.
3	1918	...	...	7	...	150	8,000	Satisfactory.
4	1918	...	...	10	...	350	5,000	Satisfactory speed was determined by requirement of tenant.
5	1917	...	...	...	15	100	10,000	Satsifactory.
6	1917	...	6	...	1	...	......	Elevators of 3-truck capacity are recommended.
7	1917	...	...	6	1	125	12,000	Satsifactory.
8	1915	...	...	6	...	100	8,000	Satsifactory.
9	1914	...	...	4	2	100	10,000	Recommended high-speed. 4-truck, 5-ton elevator.
10	1912	2	2	...	...	...	{ 5,000 } { 7,000 }	....
11*	1911	...	4	...	...	...	8,000	Satisfactory for slow turnover.
12*	1910	...	4	...	...	...	8,000	Satisfactory for slow turnover.
13	†	...	...	30	...	75	5,000	Satisfactory as to size. Recommend high speed.
14	1907	...	8	...	...	...	8,000	Satisfactory, as each tenant has an elevator for his exclusive use.
15	1901	...	5	...	...	...	5,000	Recommend 3-truck capacity.

*Supplemented by whip hoists.

†First section constructed in 1905, second in 1908, and third in 1920.

Floor Space Served by Elevator.—Table No. II shows the actual and recommended area of warehouse floor space served per elevator. The three classifications in the table assist in observing the effect of the length of turnover of goods on the elevator requirements. While the length of turnover is indefinite and, in most cases, not obtainable, the nature of the business handled justifies the classification given. The table indicates a considerable range of values particularly between the storage warehouses and those where the turnover is moderately rapid. Seldom are the exact requirements of a railroad warehouse known at the time of its construction. It is, therefore, very desirable to build a warehouse with reasonable range of adaptability, so that its usefulness will not be unduly restricted. Of the five railroad warehouses included in this study (Nos. 5, 6, 9, 10 and 14) all have been designed for moderately rapid turnover and are included under that classification. For this reason, and in order to reduce the effect of variables, only the requirements of warehouses with a moderately rapid turnover will be considered. Information on storage warehouses and others designed for special requirements will be included in all tables for purpose of comparison.

The army warehouses have been designed for a special kind of service. Two of them have their elevators located in batteries with central operator control. This arrangement, while increasing the effectiveness of its elevators, is

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*From a sub-committee report of the Committee of Yards and Terminals of the American Railway Engineering Association, presented at the 1922 convention of the association.

TABLE III.—WAREHOUSE FLOOR AREA SERVED PER ELEVATOR.

Warehouse No.	Square feet floor area served per elevator. Present	Square feet floor area served per elevator. Recommended by operating officials.	No. of tenants.	Size of elevator in capacity of 3'x6' trucks.	Remarks.
		Storage Warehouses with Slow Turnover.			
4	60,000	....	Many....	3 trucks	Satisfactory.
11	50,450	....	General storage	2 trucks	Satisfactory elevators supplemented by whip hoists.
12	57,600	....	General storage	2 trucks	Satisfactory elevators supplemented by whip hoists.
		U. S. Army Warehouses.			
1	54,084	....	One.....	4 trucks	Elevators located in batteries central control.
2	56,000	....	One.....	4 trucks	Elevators located in batteries central control.
3	73,143	56,889	One.....	3 trucks	Recommended figure best for moderately rapid turnover.
		Warehouses with Moderately Rapid Turnover.			
5†	37,406	....	Many...	4 trucks	Satisfactory.
6†	51,014	39,680	Many...	2 trucks	Recommend 2 additional elevators.
7	40,300	....	Many...	3 trucks	Satisfactory.
8	73,050	....	One.....	3 trucks	If more than one tenant were to occupy warehouse, more elevators would be required.
9†	30,733	....	Many...	3 trucks	Satisfactory.
10†	24,150	32,220	Many...	1 and 2 trucks	Present elevators not taxed to capacity.
13	42,046	....	Many...	3 trucks	Satisfactory.
15	37,140	....	One.....	2 trucks	Satisfactory.

*Column 5 divided by Column 7 of Table No. 1.

†Warehouses in connection with L. C. L. freight houses.

NOTE—Warehouse No. 14 has 18,140 sq. ft. of warehouse floor space per elevator, but is not included in above table, as it is divided into relatively small compartments with a view of leasing each compartment to an independent party, which necessitated an elevator for each section. The number of elevators installed was, therefore, dictated by conditions other than floor space and turnover of goods.

hardly adapted to the needs of general warehouse service. Their elevator service is also supplemented by numerous derricks, cranes and whip hoists. We must, therefore, be governed principally by the information contained in the third classification of the table. A review of this classification with due regard to comments in the remark column, effect of number of tenants and size of elevators, would indicate that a floor area of 40,000 sq. ft. per elevator is a reasonable allowance. (This allowance might be increased to 60,000 sq. ft. per elevator where the warehouse is used for storage purposes only.)

It might be added in this connection as a matter of interest, that some building ordinances in limiting the space between fire walls automatically limit the amount of floor area which may be accomodated per elevator.

Shipping Platform Space.—The information relative to shipping platform space required appears in Table IV. By shipping platform space is meant the area of platform adjacent to the railroad siding used exclusively for warehouse shipping. In numerous warehouses this space is made larger than required for shipping purposes in order to provide a small amount of storage space which, under certain conditions, is very desirable. The platform space for the six warehouses under the third classification, Table IV, do not include this excess space, but are used purely for shipping purposes. The amount of space actually required in proportion to the total storage area of the warehouse depends largely on the extent to which the warehouse is supplied by rail. The two warehouses in the second classification were designed primarily for rail to boat shipments and for the purpose of our study should not be given as much weight as warehouses included under the third classification. The range of values for warehouses with moderately rapid turnover is from 2.7 per cent to 5.2 per cent, with an average of 3.8 per cent. However, warehouse No. 15 is for one tenant and for a general study of this character should be considered too low.

TABLE IV.—SHIPPING PLATFORM SPACE.

Warehouse No.	Total shipping platform space sq. ft.	Total storage space, sq. ft.	Ratio in per cent between shipping platform space and total storage space.	Remarks.
	Storage Warehouses with Slow Turnover.			
11	7,370	223,900	3.3	Satisfactory
12	6,840	256,320	2.7	Satisfactory
	U. S. Army Warehouses (Marine): Shipments Principally Are Rail to Boat.			
1	14,800	3,894,000	1.2	A portion of the cars supplying this warehouse have no shipping platform and are unloaded by cranes and whip hoists.
	37,670	1,573,500	2.4	
	Warehouses with Moderately Rapid Turnover.			
3	19,800	565,500	3.5	U. S. Army warehouse. Practically all shipments are rail to rail.
5	20,860	561,100	3.7	Satisfactory.
7	12,110	282,100	4.3	Satisfactory.
8	22,700	438,300	5.2	Satisfactory.
13	50,400	1,421,000	3.5	Satisfactory.
15	5,950	221,600	2.7	Satisfactory with one tenant using warehouse.

NOTE—Warehouses Nos. 4, 6, 9, 10 and 14 are not included in this table, as their platform space is used jointly with freight house and the exact amount used by warehouse cannot be determined.

From the data given it would appear that an allowance of 4 per cent would be ample and should allow some space on platform for storage purposes. The information would indicate that 3.5 per cent might be considered a reasonable minimum allowance.

Amount of Railroad Car Trackage.—Table V contains information on the amount of railroad car trackage. The amount of trackage required depends upon the extent to which the warehouse is supplied by rail and whether the shipments are from rail to rail or from rail to team or rail to boat. It is evident that the trackage requirements should be the greatest when shipments are from rail to rail. The length of turnover also influences the amount of trackage required. Under these conditions a large variation in the amount of trackage provided at various warehouses is to be expected. In most warehouses, particularly if more than one tenant is involved, it is only possible to make one car setting per day. In other cases, where but one tenant is involved, it may be possible to make two or more settings per day. In arriving at an estimate for the amount of trackage required it is felt that an estimate should be sufficient to make possible the operation of the warehouse with one setting per day. By referring to Table V it is to be observed that Warehouse No. 1 has a very large storage space per car. In all probability, when this warehouse is being operated to full capacity, the cars are pulled two or more times per day as one tenant is involved. As has been the case in preceding tables, we must be guided principally by the data presented in the third classification of the table. The storage space per car in the six warehouses in this classification varies from 14,105 sq. ft. to 20,196 sq. ft. From the information presented, it would appear that an allowance of 17,600 sq. ft. of storage space per car siding is reasonable.

Tailboard Frontage.—The amount of tailboard space required is dependent upon the frequency of turnover and the extent to which teaming is used as a means of handling goods to and from the warehouse. The warehouses listed in

TABLE V.—WAREHOUSE FLOOR AREA PER CAR LENGTH OF SIDING.

Warehouse No.	Shipping space.	Storage.	Sq. ft. of storage space per car of siding.	Remarks.
	Storage Warehouses Where Turnover Is Slow.			
11	5,820	223,900	27,988	Satisfactory for slow turnover.
12	5,400	256,300	28,477	Satisfactory for slow turnover.
	U. S. Army Warehouse (Marine).			
1	42,360	3,894,000	41,871	Warehouse used for reservoir purposes. When boats are being loaded warehouse shipments are supplemented by handling cars direct to docks.
2	37,674	1,573,500	17,483	Satisfactory. (Same note as for No. 1.)
	Warehouses Where Turnover Is Moderately Rapid.			
3	19,800	565,500	20,196	Designed largely for rail to rail service and has proven satisfactory.
5	20,860	561,100	17,534	Satisfactory.
7	12,110	282,100	14,105	
8	22,700	438,300	18,262	Satisfactory.
13	50,400	1,421,000	14,210	Superintendent recommends 19,736 sq. ft. per car.
15	5,950	221,600	20,145	Satisfactory with one tenant using warehouse.

NOTE—Warehouses Nos. 4, 6, 9, 10 and 14 are not included in this table, as their shipping space is used jointly by freight house and warehouse and the exact amount used by warehouse cannot be determined.

Table No. VI have been divided into three classes to assist in illustrating the effect of the variables above mentioned on the amount of tailboard space required. The information given for the warehouses under the first classification will not be of value in this study and that under the second classification will be of value for comparative purposes only. Unfortunately, there remain but four warehouses under the third classification where the turnover of goods is moderately rapid and in the case of warehouse No. 15 the tailboard is supplemented by lighterage shipments. The table shows the amount of tailboard frontage in comparison to both the storage space of the warehouse and the amount of railroad trackage. The relation with the former will first be considered. The floors for warehouses 7, 8 and 13 vary from 861 to 1,306, with an average of 1,030. This is a large range and insufficient data from which to make a very valuable suggestion as to proper allowance of tailboard space, but it would appear from the figures presented and observation of the warehouses that an allowance of 1,100 sq. ft. of warehouse floor space per foot of tailboard frontage is reasonable.

If we use this figure and the suggested 17,600 sq. ft. of storage space per railroad car, it follows that 16 ft. of tailboard frontage should be provided per car. By referring to the fourth column in Table VI under the third classification, it will be noted that the values for warehouses Nos. 7, 8 and 13 vary from 10.8 to 19.8, with an average of 15.7. The values for the last two mentioned warehouses, which are recommended figures, are above this amount. It, therefore, appears that 16 ft. of tailboard frontage per car of siding is a reasonable allowance.

Summary.—Summarizing the foregoing report as to the suggested relation between the various factors of design, we have the following, which are suggested for warehouses where the turnover of goods is moderately rapid.

1. One elevator should be provided for each 40,000 sq. ft. of warehouse space served.
2. The shipping platform area should be 4 per cent of warehouse storage floor area.
3. There should be one car length of track siding for each 17,600 sq. ft. of warehouse storage area.
4. There should be one foot of tailboard frontage for every 1,100 sq. ft. of warehouse storage area.
5. There should be 16 ft. of tailboard frontage for each car length of siding.

The above figures do not represent exact limits of design, but are indicative of the proper relation which should exist based on experience of the warehouses studied in this report. An idea of the permissible variation from these figures may be obtained by a review of the foregoing tables.

TABLE VI—TAILBOARD FRONTAGE.

Warehouse No.	Sq. ft. of storage space per foot of tailboard frontage.†	Remarks.	No. of feet of tailboard frontage per car of siding.*	Remarks.
Warehouses Where Shipments Are Primarily From Rail to Boat or Rail to Rail, and Very Little Teaming Is Done.				
1	2 135	Satisfactory	19.6	Satisfactory.
2	1,639	Satisfactory	10.7	Satisfactory.
3	6,283	Practically no teaming.....	3.2	Practically no teaming.
4	5,941	Very little teaming.........	....	Cannot separate between warehouse and freight house (siding).
Storage Warehouse Where Turnover Is Slow.				
11	2,239	Satisfactory	12.5	Satisfactory.
12	2,563	Satisfactory	11.1	Satisfactory.
Warehouses Where Turnover Is Reasonably Rapid.				
7	1,306	Satisfactory	10.8	
8	1,231	Supt. recommends 925.....	14.8	Supt. recommends 19.8.
13	1,421	Observation Indicates that 861 are required.	10.0	Observation indicates 16.5 to be correct.
15	2,216	Supplemented by shipment by lighters, which tends to increase this figure...	9.1	Supplemented by shipment by lighters, which tends to lower this figure.

*Column 9 divided by Column 8, Table No. 1. †Column 6 divided by Column 9, Table No. 1.

Note—Warehouses Nos. 5, 6, 9, 10 and 14 are not included in this table, as facilities are used jointly with freight house and exact amount used for warehouse purposes is not available.

Establishing Permanent Base Lines in Industrial Plants

The necessity of establishing permanent base lines as a locus standi for engineering work in industrial plants has been greatly underestimated. In a great number of plants no permanent reference line is found and in many it is only vaguely located. This is more true of the older than the modern plants. The development of a type of permanent base line which is adaptable to any industrial plant, is described by J. Le Roy Underhill in a recent issue of The Canadian Engineer, from which the notes folowing are taken.

Important Factors in Fixing Line.—In fixing such a line a few important factors should be considered.

First—Permanency is essential.

Second—Its adaption to a location which will at all times afford an unobstructed view between at least two monuments.

Third—The line should at all times be accessible for both measurement and instrument work. In this case it is well to consider future plant extensions when locating monuments. Obviously some of the monuments will be destroyed as time passes, but if a base line is to be maintained, provision should always be made for its re-establishment when necessary.

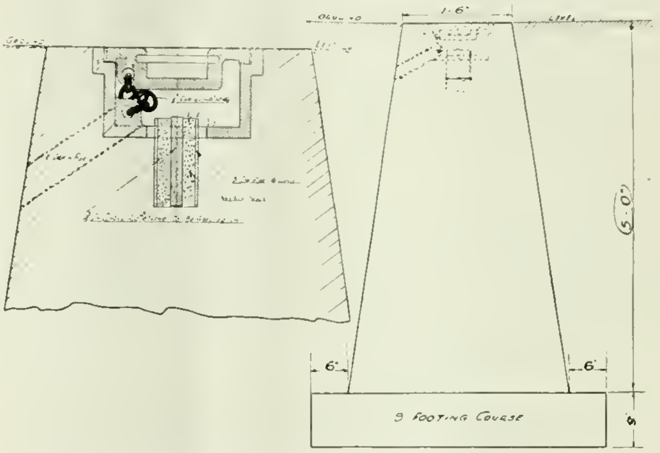

Fig. 1.—Monument in Elevation.
Fig. 2.—Section of Top of Monument Showing Center Plug in Place.

Fourth—Monuments should be located so as not to be an obstruction. In this case the only remedy seems to lie in making them flush with the ground, thus not affecting the passage of roadways, tracks, etc. Frequently the only unobstructed territory in a plant is along a track or roadway. In order to allow the placing of monuments in exposed places, such as directly in a roadway, a special casting has been designed to fit into the top, and in which the center point is placed.

Establishing a Base Line.—The following sketches and descriptions should give the reader a clear understanding of the methods followed throughout in the designing and establishing of such a base line.

Figure 1 shows the concrete monument in elevation. The dimension encircled is variable and may be changed to suit local conditions. Figure 2 shows a large scale section of the top of the completed monument, with the center plug in place. A section of 3-in. pipe, 6 in. in length, is inserted in the bottom of the plate, in which to grout the center plug after the concreting of the monument has been completed. The center plug mentioned above is a ¾-in. round copper rod, 6 in. in length.

Methods of Locating Lines and Placing Monuments.—The method of locating the line and placing the monuments is as follows: First, the line is fixed on the ground and the location of the monuments marked. In order to facilitate the making of measurements, each monument should be set at some convenient chainage, e. g. an even station plus 10, or a multiple. Should it occur that the above chainage can not be obtained, set at least to an even foot. Then excavation for the monument is carried down to the required depth. In countries where frost occurs, care should be taken to excavate below the frost line. Footing courses 9 in. thick are poured and the forms for the monument set in place. It is always wise to place a footing course under each monument, as it counteracts any tendency to settle. After the forms are set, they should be carefully lined in and checked for chainage, and the plate, with pipe inserted as shown in Fig. 2 should be placed in its proper position. The drain pipe should also be placed in position, the actual slope given being sufficient to carry off any water which may collect. When this is done, they may be filled with concrete, using a 1:2:4 mixture. Before the center plugs are finally lined in and centered, time should be allowed for the concrete in the monument to set.

When everything is in readiness for the final work of establishing the line, a small quantity of very rich concrete is prepared and placed in the pipe in each monument. The copper plugs are quite easily driven into this, lined in with a transit and carefully set at the required chainage. After the plugs have been thus set, great care should be taken not to disturb them until the concrete in the pipe has sufficiently set to hold them in place, when precise line and chainage may be marked on them. The most convenient center mark, which answers tor both line and chainage, is a cross scratched on the head of each plug with a sharp-edger tool. It is wise to make each cross accurately with a pencil first. Great pains should be taken to have all plugs accurately centered, the work being done with an instrument which is in perfect adjustment. Should any doubt be entertained as to the adjustments, the instrument should be reversed on all points given in order to eliminate any possible chance of error. In chaining the distances it is well to check and recheck all measurements with a chain or tape which is accepted as standard. It is especially necessary to re-check all measurements made under unfavorable conditions.

This finishes the work as far as line and chainage go, and now comes the task of running a line of precise levels on the center plugs. The elevation of each plug should be very carefuly noted. In this also great care should be exercised to have all elevations exact, and tied into some accepted bench mark previously set.

Effect of a Safety Organization on Insurance Costs

An excellent example of the beneficial effect of an efficient safety organization in a ship building plant was cited by Jos. A. Garrett in a paper presented March 15 before the Southern California Society of Safety Engineers. The plant referred to was that of the Los Angeles Shipbuilding and Dry Dock Co.

At the time the safety work was undertaken, the company was self-insurers. After four months' operations, it reduced the cost of insurance and medical service from $3.18 per man to $1.32 per man—a net saving of 58 per cent; the payments for compensation were reduced from $3,950 per month to $600—a net gain of 85 per cent; and during this time there was but a net change of 15 per cent reduction in its working force. The "frequency" rate dropped from 140.5 to 61.3 and the "severity" rate from 1.15 to .573. Another example of the value of thorough safety organization is the Moore Shipbuilding Co., Oakland, Cal. The safety organization there was combined with the self-insuring department and within a three-year period the combined departments completely financed a capital investment of $100,000 in addition to meeting all operating expenses of the departments paying in full all compensation due account personal injury claims and made a further saving which was the means of regular dividend distributions to the stockholders.

Effect of Organic Matter in Concrete to Be Studied.—Sands unsuitable for concrete on account of the presence of loam or other organic matter are to be investigated by the Bureau of Public Roads of the United States Department of Agriculture and methods of treatment devised to make them safe for use. A few years ago laboratory workers discovered the effect of organic matter in sand and devised a simple test to determine its presence in harmfulquantities. The bureau now hopes to find methods of treatment so that such sands can be used. Samples of sand from all parts of the country are desired and anyone is invited to send in a sample in which the presence of organic matter is suspected, addressed to the Bureau of Public Roads, Washington, D. C.

The Danger of Shoddy Construction

An Address Before the Civic Development Group Chamber of Commerce of United States

By LYMAN CLARK,
Of General Electric Co., Lynn, Mass.

As there can be many interpretations given to the subject of "Dangers of Shoddy Construction," it may be best to paraphrase by stating that "dangers" refers to economics; "shoddy" refers to waste due to materials or personnel, and "construction" refers to building structures either commercial, industrial or residential.

Building construction in the United States involves the expenditure annually of an amount probably equal to three billion dollars. The very smallest economic effect upon this expenditure naturally involves a large sum of money and we may readily afford considerable expense in devising methods for its economic use. As an example, if our annual outlay for building construction can be affected by only such a small amount as 1 per cent for good or for evil, or 1 per cent positive value and 1 per cent negative value., we have the possibility of creating a saving account of 2 per cent or sixty million dollars annually which is the interest charge at 6 per cent on a total of 33 1-3 per cent of our annual expenditure. With this large saving in mind, is it not worth while to seriously look ahead and devise every possible means for the reduction and prevention of shoddy in building construction?

Causes of shoddy construction:

A. Ownership.
B. Construction.

A. Ownership.—There are many causes for shoddy construction that are traceable to the ownership of property. We look upon property in the sense of invested capital upon which we must seek a financial return. Our constant thought is to develop the property for one purpose or another, that it may make a return on the invested capital. From the standpoint of building construction the owner is always confronted with the problem of what best can be done with his property from two points of view; he must consider the property in the light of a holding with ever increasing value or he must consider it in the light of something to be traded in as an article of commerce. Where the owner has adopted the latter consideration, there springs up within our urban and suburban centers an enormous amount of building construction.

There is a cause for shoddy construction where the owner tries to seek a greater earning increment by attempting to build beyond his means. Without sufficient capital requirements, he often places upon the property a building of the dimensions and contents he desires by utilizing shoddy construction. In other words, he is forced to build beyond his borrowing ability.

B. Construction.—It is questionable whether more shoddy is used by those having to do with the actual construction of buildings than those who are concerned in the ownership of property and buildings. In the construction work, we have to consider the following responsible personnel: (1) Architects and engineers; (2) general and sub-contractors, and (3) labor.

There is probably no profession upon which is imposed a greater necessity of knowledge than that of architecture. In the architect's relations to shoddy construction we may truthfully state that ignorance is the only possible avenue for its introduction. Sometimes this ignorance is due to a "closed ear" on the architect's part from his inability to receive or lack of appreciation of advice but it is seldom if ever the question of wilful introduction of shoddy construction by him, a condition which does not always pertain to the owner.

Reduction of shoddy construction:

1. Loans.
2. Regulations.
3. Education.
4. Co-operation.

1. Loans.—While it may be a delicate question to impose upon him who loans funds for building purposes, a further consideration than the return of interest and principle, there, however, seems to be a growing consideration that financiers must be more concerned with this question than they have in the past. The mortgagee of property should be concerned not only in the insurance that principle and interest are returned but that the loan has been wisely and judiciously invested. It should be the duty of one loaning money for buildings to know that the character, kind and quality are the best within economic means. The life of building structures has been variously estimated as being for cheap frame tenements of from ten to fifteen years and for the best structural buildings of from seventy-five to one hundred years. A rate for sinking funds would then be 10 to 5 per cent for the cheap frame tenements for a term of nine to sixteen years. In the structural buildings the rate of the sinking fund would only need to be 1 per cent and the term only one-half its life. Therefore, we may reduce the introduction of shoddy construction by impressing upon the owner the economical considerations of building well, and further, by making it difficult to obtain loans for shoddy construction. We may be able in this way to reduce shoddy construction by placing a premium upon good construction.

2. **Regulations.**—We have comparatively few cities with what are municipally known as building codes and none of these codes absolutely prohibit the use of shoddy construction. In the majority of cases they are made out for the purpose of creating fire walls but do not go very far into the character or necessities of good construction. We have various rules for fire protection which more or less define the kinds of materials but again these materials are merely to prevent fire hazards rather than to create good construction. While there are inspections of one sort or another for urban and some suburban properties there does not seem to be such regulation that prohibits or reduces to any marked extent a considerable amount of shoddy construction. Attempts have been made, however, to clarify and unify many regulations imposed upon the building structure. We may, therefore, hope by this means to greatly reduce shoddy construction in future buildings.

3. **Education.**—It is possible to reduce the use of shoddy through many educational facilities. Considerable good work has been done along these lines, not only in the technical press but in popular magazines, newspapers and circulars. That considerable mere can be done in our schools and educational institutions, there can be no question. The building public should be advised as to the economic advantages of quality materials. Considerable benefit in the building industry might accrue also from visual instruction through the use of motion pictures distributed by manufacturers and others.

4. **Co-operation.**—Probably no better means for reduction of shoddy is provided than through co-operative effort stimulated by trade associations. There has been a tremendous amount of work done by trade associations in setting up useful and economic standards that have materially reduced the waste in building structures. There is still a great deal of work to be done and it would seem worthy to propose that wherever possible, various trade associations should be notified by the architectural profession, by the engineering societies and by various contractors' associations of anything that will tend to reduce the use of shoddy by its removal from the market.

We are confronted today in the construction industry with the price of labor sufficient to necessitate the use of only good material and certainly entire elimination of shoddy material. It is impossible to conceive of paying the prevailing rates of labor for the introduction of shoddy. If one will undertake to examine the material in the market, it will be clearly and easily seen that the use of good material does not vitally affect the cost of building structures; that those concerned with building operations do not examine thoroughly the market price of commodities in planning building structures must be evident. We, for instance, do not find a marked increase in the use of copper at a price in the neighborhood of 13½ ct. over the use of copper at the price of 26 ct.; we do not find a marked increased use of rubber at 13 ct. over its normal price of 90 ct. or during the war at $3.30.

In residential building, we are confronted with a condition where about one-half the cost goes to labor and one-half to material. Eliminating certain items of material that are by an average amount equal to 10 per cent, we can figure on obtaining a home in the definition of Webster: "The abiding place of affections." Generally, quality may be obtained at an expense of only 2½ per cent of the total cost.

Arc Welding of Structural Steel Framework*

By H. L. UNLAND,

Power and Mining Department, General Electric Co.

Arc Welding in Ship Construction.—In 1918 the value of electric arc welding in ship construction was realized in this country and in England. The Marine Classification Societies agreed on a long list of the minor parts of a ship where welding was permitted but the subject was left open by a foot-note to the effect that welding of parts of the ship, other than those listed, should be referred to the Classification Society for approval of each individual case. The United States Shipping Board laid out an extensive program for the application of arc welding to ship-building. This included the training of welders as well as the design work necessary to adapt ship construction to the minor application of welding. Also, designs of ships were made up in which welding only was to be used in the fabrication. This necessitated the building of special shipyards for which the plans were completed when the war ended. Due to the lull in shipbuilding, the development was not carried further, but the decision to start it was made after thorough investigation and trial.

The methods used for structural steel welding will be similar to those used in marine construction since the construction consists of joining structural steel shapes and plates into one rigid structure.

Butt Weld and Lap Weld Joints.—Within the past three or four years many thousands of tests have been made to show the characteristics of electric arc welds but the tensile tests have, in practically all cases, been based on a straight butt-weld of two plates. This type of weld does not lend itself to structural steel work nearly so well as a fillet-type lap-weld. On this type of weld, however, there is very little actual information as to results of tensile tests.

In the straight butt-weld, the stress lies practically in line with the weld but, in the case of a lap-weld, there is a bending stress which throws the plates out of line and causes a tearing action to occur. It is well known that if a tearing stress can be applied to a weld, the strength of the weld will be lower than in case a straight tensile stress can be applied. Deposited metal is found to be satisfactory where it is to be used in compression, the average strength of the metal being 40,000 to 50,000 lb. per square inch in either tension or compression.

The results of the few tests of lap-welded samples of which record could be found showed that a double lap-weld would, in many cases, break outside the weld, showing that the joint was stronger than the original plate. Of course, these tests were part of the series made by and for the United States Shipping Board, consequently the work was all done by skilled operators after preliminary practice on similar plates. This latter point is of considerable importance as the change from light to heavy work or from butt-welds to fillet welds, etc., involves a change in the current and sometimes in electrode size as well as the manipulation of the electrode. Reports of tests made by Lloyd's Register of Shipping were given in the December, 1918, issue of the General Electric Review. These tests showed that a lap-weld with a full fillet at each edge averaged from 70 to 80 per cent of the strength of the plate which was about 60,000 lb. A triple-riveted lap-joint was stated to have an efficiency of 65 per cent. These tests indicate that, in the case of the lap-welded joint, the strength of the joint would be greater than that of a riveted joint if the weld had a total length equal to twice the width of the plate. In all cases the weld formed a full fillet the entire thickness of the plate.

Tests of Lap-Weld Joints.—In order to check these figures, a number of samples were made up. An average operator was instructed to make three lap-welds of 1½ by ¼-in. iron strips. A 1½-in. angle was assumed to have twice the length of cross-section of the 1½-in. strip, or that it was equivalent to a strip 3 in. by ¼ in. On the basis that the weld would be twice the section width, there would be required 6 in. of weld in the case of the angle-iron. This was obtained by lapping the angle-iron over the edge of a 2⅞ by ⅜ in. bar, and depositing 3 in. of weld on each side of the angle-iron. In order to determine the effect of bending stress, a 1½-in. angle-iron 19 in. long, was welded to a 3-in. angle, 24 in. long, to provide a 2-in-1 pitch representing the ordinary roof slope. This was placed in a testing machine and pressure applied to close the angle. The results of these tests are as follows:

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*From a paper presented before the Engineers' Society of Western Pennsylvania.

LAP-WELD TWO PIECES, ¼ BY 1½-IN.

Yield-point.		Failure.	
Lb.	Lb. per sq. in. (Based on section of strap.)	Lb.	Lb. per sq. in.
16,590	44,000	24,350	64,800
15,100	35,000	19,370	51,000
16,670	44,500	23,060	61,500

In one case the strap broke outside the weld, but the other two broke in the weld by tearing, when the straps bent under the tension. Inspection of the welds showed that the current used had been too low and that the penetration and adhesion were not satisfactory. In spite of this, the poorer joint had 80 per cent of the strength of the plate.

LAP-WELD 1½ BY 1½ BY ¼-IN. ANGLE TO 2⅞ BY ⅜-IN. STRAP.

Yield-point.		Failure.	
Lb.	Lb. per sq. in. (Area of angle, 0.69 sq. in.)	Lb.	Lb. per sq. in.
19,350	28,000	31,700	46,000
15,310	22,200	32,450	47,000
17,770	25,800	32,980	47,500

In all cases the welds gave way, but only after the angle-iron and strap had been deformed to such an extent as to subject the weld to a tearing action. It will be noted that the breaking strength was almost twice the yield-point of the angle, which was considerably deformed, as shown in the illustration. The test of the two angles welded together, in which the weld was subjected to a bending force, showed that in this sample, the weld, even when placed in a position where eccentric loading took place, was stiffer than the angle-iron since the 1½-in. angle passed the yield-point and was merely deformed without greatly increasing the force required. The yield-point was passed at a force of 890 lb. applied to the end of the 1½-in. angle and in a direction perpendicular to the 3-in. angle, thus giving a component at right angles to the 1½-in. angle of 796 lb.

These tests indicate that, in order to obtain the greatest strength, it is necessary to design the joints so as to eliminate tearing action on the weld. In the case of the samples tested, this could be accomplished by placing an additional length of weld joining the smaller angle-iron or structural section to the larger one, and locating this weld at the point where the stress tends to separate the two pieces. In the samples tested, this would be across the end of the strap back of the angle-iron, and in the case of the two angle-irons would be along the top of the 3-in. angle. The procedure would not only increase actual length of the weld but would place it at a point where the benefit would be the greatest.

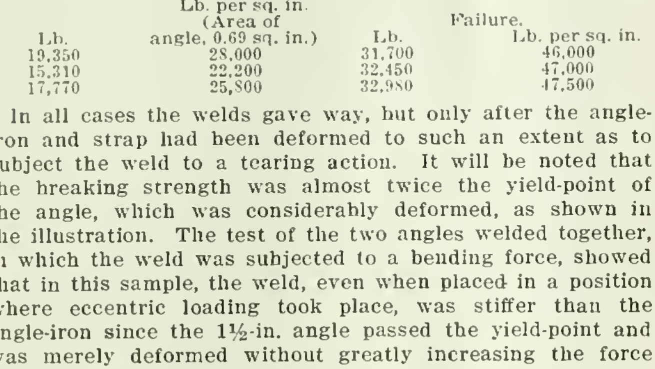

Fig. 1.—End Elevation Welded Steel Frame Shed.

Proportioning Welds.—If this proceeding were followed, there is little doubt but that practically all joints would break outside the weld. The welds tested were proportional on the following basis: The length of a lap-weld is twice the section length of the smallest section to be joined. A 1½-in. strap of iron would require two welds, each 3 in. 1½-in. angle section would require two welds, each 3 in. long, or a total of 6 in., for the angle-iron would have a section length of twice 1½-in., or a total of 3-in. Based on a tensile strength of 60,000 lb., these tests had an efficiency of 78 per cent. A ½-in. rivet in this joint would reduce the section of the small angle to 80.5 per cent which would be the maximum strength of the joint obtainable with ½-in. rivets. It can be seen from the figures that the load at which failure occurred was approaching the value of twice the yield-point. In other words, the small angle-iron was badly strained and was probably approaching the breaking point. It is very difficult to clamp an angle-iron in the jaws of a testing machine, so it was impossible to obtain the strength of the angle. These tests indicate that the lap-weld should have a length of twice the section length of the smaller section, with an additional weld of half the section length so placed as to prevent tearing apart of the two pieces. This figure applies to sections in which the smaller section is ½ in. thick, or less. If the section increases in thickness above this value, the factor should be increased to three for thicknesses of ¾-in. This is on account of the increasing difficulty in obtaining thorough fusion as the thickness of the plates increase.

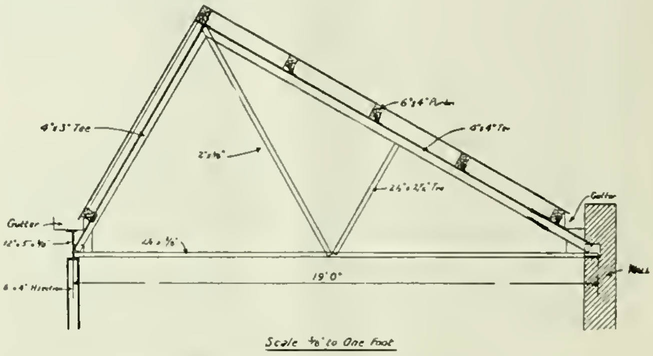

Fig. 2.—Construction of Saw-Tooth Roof.

Speed for Making Fillet Weld.—For various thickness of section, the speed of making a fillet weld will be approximately as shown in the following table:

Thickness of section. In.	Amperes.	Kilowatts.	Inches per minute.	Electrode pounds per inch of weld.
⅛	85	5.1	3.5	0.005
3/16	100	6	3	0.01
¼	125	7.5	2.5	0.02
⅜	150	9	2.2	0.04
½	180	10.8	0.75	0.07

English Welded Structure.—To show that the subject is not merely of academic interest, at least one company in England (Welded Construction, Ltd.) is putting this process into practice commercially. The first commercial structure entirely welded was a steel-frame shed used as stables for the Olympia Horse Show, in 1920 (Fig. 1). This building covered ground space of 9,000 sq. ft. with a width of 14 ft. The construction, of course, was very light, but by the use of a simple gig, two welders and four helpers completed ten trusses per day. The structural pieces were cut to length and shipped to the site where the trusses were welded. Caps and baseplates were welded to the columns on which the trusses were later placed and welded. It will be noted that gusset-plates were used at a number of points in order to obtain the necessary length of lap. Using the basis given above for estimating the amount of welding, such a truss would require about 143 in. of weld, which would take approximately one hour. The remaining time would probably be taken up in checking and locating the various members of the jig.

Method of Constructing Saw Tooth Roof.—The next step was the construction of a saw-tooth roof (Fig. 2). In this case the truss was much simpler, although the members were of heavier section and the span was greater. In these trusses, gusset-plates were unnecessary. In this building the steelwork is all welded. The procedure in construction is as follows:

Columns are cut to length, and caps and base-plates welded on at the site, after which they are set up. The joists are hoisted into place on the column cap plates, and welded, being held in place by clamps. The trusses are constructed on the site, since the members are cut to length on the job, and by the use of a simple steel fixture the members are properly located, after which they are welded. The trusses are hoisted into position and welded. The cost figures given on this installation are as follows:

Labor—Welder at 60 ct. per hour	$1.54
Material—Electrodes	.68
Power at 4 ct. per b. t. u.	.06
	$2.28

One welder and one helper, after the material is cut to length, average 1½ hour per truss, although they have completed the welding in 50 minutes. The attaching of the caps and base-plates to the columns requires approximately one-half hour. Welding a truss in place requires ½ hour. Based on English practice the erection of this building showed a reduction of 50 per cent in the erection cost.

Erection Method for Machine Shop.—A more ambitious contract covered a machine-shop having a central bay 40 ft. wide, and wing bays 15 ft. wide. The methods used in the construction of this building differed somewhat from those previously described. The columns were prepared at the plant of the welding contractor. After the foundations were completed, these columns were shipped and erected and the joists placed and welded on top of the columns. The trusses were constructed in halves at the contractor's plant, these sections being shipped to the site, erected, and finally welded in place. In welding these trusses, the steel locating fixture was again used. It was unnecessary in this construction to use gusset-plates. The attachment of the compression members alternately on the two sides of the tension members will also be noticed from the illustration. No rivets or bolts were used in any of the work on the structure.

Equipment for Welding.—One point that should not be overlooked in the comparison of the equipment required for welding as against riveting, is that there are no holes improperly located to be laboriously corrected during the erection. There is one welding equipment, in contrast with the multiplicity of clamps, bolts, wrenches, hammers, and in some cases air-compressor equipment. The experience so far, in this particular field, indicates that much of the welding will be done on the site. If electricity is availbale, of course the proper welding equipment will be a motor-generator set driven by an electric motor. It will be necessary, however, in a great number of cases to erect structures where no power is available; in which case, arc-welding equipments driven by some form of engine will be desired. For this application, the small single-operator equipments have advantages over the larger multiple-operated equipments. Of course, there may be cases where a number of welders will be located together and here a multiple-operated equipment may be used to advantage, but there will be many cases where a single operator will be located at a considerable distance from any other welder. These conditions will probably obtain to a greater extent than will the grouping of welders.

An equipment consisting of a single-operator, arc-welding generator driven by a two-cylinder gasoline or kerosene engine provides a very satisfactory unit for the isolated work. This unit starts on gasoline and changes to kerosene for continuous operation. In case it is desired to operate two welding generators from the one engine, this equipment provides very satisfactory means of accomplishing the result. Two generators are mounted on the supporting frame, one being driven by a sprocket on either end of the engine shaft, the fuel tank being moved to a point between the two generators. Gravity fuel feed is used with individual carbureters for the two cylinders.

In this field, as in practically all others, the success of the application depends upon the company taking up the work. There will be many people available to give advice but the problem of design and methods is one to be worked out individually.

New Publications on Paint.—The second editions of Circular 90, "United States Government Specifications for Red Lead, Dry and Paste," and Circular 97, "United States Government Specifications for Green Paint, Semipaste and Ready Mixed," became available for distribution on June 19. It should be noted that the titles have been changed from the first editions, that is, they now read, "United States Government Specification" instead of "Recommended Specification." Circulars 82, 84, 85, 87, 88, 89, 91, 93, 94, 111 and 117 have been ordered printed as revised with similar changes in title. All of these publications may be obtained from the Superintendent of Documents, Government Printing Office.

Reducing Unemployment of Labor and Capital in Construction Industry*

By A. P. GREENSFELDER
Of Fruin-Colnon Contracting Co., St. Louis.

One of the most costly and serious problems of our whole construction industry is due to unemployment—both of capital and labor. We are apt to think of idleness only in terms of man power, but as capital can only produce and wealth increase by the application of that man power it behooves us to realize that their interests are common. We must further remember that unless the laborer earns, he has but little to spend; and his demands for goods and shelter are what produce the insistence for the supply which capital helps create.

Summer Sunshine Overcapitalized.—The construction industry of all our industries next to agriculture, has been possibly the least concerned and yet the most affected by unemployment. We seem, until quite recently perhaps, to have taken it for granted that because field construction is largely conducted out of doors, it must necessarily be governed by the weather and conditions incident thereto. Summer sunshine has been and still is overcapitalized. Because field construction seldom has a roof over its factory we fail to view it as a producing factor of the same potentiality to equal capital invested within an inclosure.

When a construction project is idle for any cause the invested capital is idle, the alloted workers are unemployed and the producers and conveyors of construction materials are seriously interrupted. The total cost of this unemployment is a vast sum unnecesarily added as a wasteful annual expense to the whole industry and each integral part.

Waste in Building Industry.—A valuable attempt to measure such waste in the building industry is noted in the study initiated by Secretary Hoover, through American Engineering Council last year. Sanford E. Thompson, consulting engineer of Boston, who applied the principles of industrial waste to the building business, in such printed reports calls particular attention to this irregular employment and the expenses caused thereby. He states that due to an average of only 190 working days a year for field construction the loss to the nation from this cause alone is approximately $100,000,000 annually. If we added to this the interest during construction, the idle labor, material and transportation facilities of dependent quarries, mills, shops and ways, the total loss is enormous.

Can the construction industry be so blind to its own self-interest as well as its duty to the nation not to realize the necessity of reducing this burden? Cannot brick makers, steel producers, railroad men, designers, contractors and laborers realize that continuous employment means better annual earnings and yet cheaper production? Cheaper prices mean greater demand and this in turn provides continuous employment. Reduced costs per cubic foot of structures, be they stores, schools, or houses, means increased volume of demand. Homes at $1,000 per room will create more than twice the demand than will the same values at 50 per cent increased cost.

Causes of Seasonal Fluctuations.—Having diognosed the disease and the public burden thereof, let us study the causes and endeavor to provide possible remedies. The principal causes are (1) seasonal fluctuations, (2) bad weather, (3) labor strikes and lock-outs, (4) inefficient management, and (5) restricted production. Careful analysis of each of such causes, resolute endeavors to correct them and an earnest spirit of co-operation will gradually produce results. Some results of large measure can undoubtedly be secured with one year and others will rapidly follow as the movement progresses. Seasonal fluctuations are largely because of old fashioned customs. Before the days of mechanical field equipment construction progress throughout the year was seldom contemplated. Today such reasons do not control. Land values and production demands for floor space now outweigh minor variations in seasonal costs and a proper educational campaign through concerted nationally-directed advertising can do wonders.

Winter Work.—"Winter made buildings" can be made just as popular as "summer made rice." A "plan early" crusade can be made equally effective as a "winter-let contract" by proper inducements of seasonal discounts in material prices, freight rates, wages, and the superimposed planning, supervising and financial commissions.

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*From The Constructor.

Bad weather is purely a relative condition and much good can be mixed with it. Ordinary winter temperatures can be easily moderated by the judicious application of heat, and wind, snow and rain can be excluded by canvas and common sense. If $1,500 is a fair annual wage for skilled labor this may be earned at the rate of $7.50 per day for 200 working days, or at $5.00 daily for 300 days. Henry Ford has thoroughly demonstrated that the latter rate is sufficient, highly profitable to himself and tremendously useful to the public. Competent labor can be attracted to low turn-over industries when fairly paid and cared for. Bricks, steel and lumber do not freeze—only fingers and mortars for an average of 20 days and the cost of applying gloves and anti-freezing remedies is relatively small in most United States latitudes as compared to the "unearned increment" lost in waiting. The cold weather differential is only a few per cent and can be readily off-set by reduced prices or one-half hour longer labor per day for winter months.

Losses Due to Strikes and Lock-outs.—Labor strikes and lock-outs are human factors needing the sunlight of broad self-interest, food of facts and careful, competent and co-operative nursing to cure them of their cancers. The National Board for Jurisdictional Awards in the Building Industry, so well described in the Nation's Business for April by President Bent of the Associated General Contractors, is evidence of possibilities and practical results in eliminating strikes. Industrial labor boards in factory, field and nation can largely reduce unemployment due to labor disputes. It is estimated that 500 strikes and lock-outs a year waste 3,000,000 man-days alone in field construction exclusive of probably large figures for production of construction materials. Employers and employees should jointly study the labor problems and their true relationships if we are to progress in skill, safety and satisfaction in this industry. The public is learning that it pays "the bill of costs" for every effective "bill of rights," and as soon as it obtains the correct figures it is beginning to demand each industry either must arbitrate all of its labor differences or it will be done for them in legalized industrial courts. Let us lead the way, and raise facts instead of factions in the construction industry.

Inefficient Management as Cause of Unemployment.—Inefficient management is a real tangible producer of unemployment and is a man-sized job to tackle. Production analysis may be a new term to the construction industry, but it is a vital element in the elimination of waste. Production schedules, planning, routing and expediting materials so as to avoid delays and shut-downs are real responsibilities of managers. Proper maintenance of plant and machinery not only prevents breakdowns and labor lay-offs, but pays dividends well worth the earning. Employment managers must be made if they cannot be found, because labor turnover rates in the industry are a disgrace not only due to the previous causes, but due to the irate desire of pin-headed bosses to exercise and show their authority. Transferring men to the right jobs is better than firing, and nothing is quite as needless and expensive as training and hiring. Let us determine a fair day's work for a fair workman and a fair day's pay will soon take care of itself.

Unenlightened Labor Restricts Production.—Restricted production is largely the result of unenlightened labor. Discouraging experiences of piece work, price reductions and replacement by machinery without consideration of the employee have undoubtedly had their effect on labor in its attempt to avoid unemployment by restricting production. Discouragement of apprentices, restricting output of skilled men and reducing dilution by unskilled labor all have been influenced by the dread and fear of unemployment. Organizations of labor are perhaps more often formed to combat such practices than to protect themselves against wage reductions, but that they have gone to the other extremes in many cases, especially in the last few years, is needless to say. Vocational training simultaneous with apprenticeship, profit sharing, insurance for accident, illness, unemployment and old age are possibly measures for investigation in order to remove the fear of hunger and instill a recognition of real pride and craftsmanship both in quantity and quality production.

Building to Resist Earthquakes

California Architect Discusses Essential Requirements*

By SUMNER HUNT

President, Southern California Chapter American Institute of Architects.

This paper is a plea to architects and building contractors to remember that in any country earthquakes are a possibility and in some countries a practical certainty, and to consider the effect of earthquakes on the buildings they plan and erect.

Outside of geologists, who look upon earthquakes as a more than ordinarily interesting phenomenon and not as a terrifying one, the American public, generally, including even architects and building contractors, in localities where earthquakes are prevalent, are prone to emulate the ostrich who hides his head in the sand to protect himself from danger, and refuse to admit the fact of such a thing as an earthquake.

It is time we, in California particularly, admit the probability of earthquakes and learn that properly built structures will withstand, without serious damage, earthquakes of as great severity as any that have occurred here in the recorded past.

For the purpose of this article, "Class A" buildings will be but lightly touched upon, as the evidence shows that either a steel frame, or a reinforced concrete frame, engineered according to generally accepted formulae, will withstand the severest shocks; the only weakness developed in buildings of this class being from poorly built filler walls and poorly secured applied facing material and ornamental features.

The simple device of using light reinforcing and good cement mortar in filler walls and ordinary care in tying in of applied facing material and ornamental features will make these buildings perfectly safe. Perhaps the ideally earthquake-proof building is the well engineered monolithic reinforced concrete structure, in which the structural material forms the finished facing, without the application of a veneer material, but as this in street architecture is generally not sufficiently rich or decorative, the opportunity for its use does not often occur.

As to buildings other than "Class A," an almost sufficient formula for earthquake resistance would be the simple one of building well instead of poorly, using the age old understanding of what constitutes good work.

In masonry walls, for instance, it is always the walls built with poor mortar that crack or fall. A good story illustrating the soundness of the good work formula comes from a committee sent some years ago to the Imperial Valley to investigate the results of an earthquake there. The committee noted a considerable number of complete wrecks of buildings, built of cement blocks for the outer walls, and also noted other buildings of apparently the same construction that showed little or no damage. Investigation brought out the fact that these buildings, the wrecked ones and the ones standing in good condition, were all built by the same contractor, but the buildings in good condition were built by the contractor for himself. The moral is obvious.

As to details of good construction for earthquake resistance, we will start with foundations. They should be deep enough and heavy enough to insure against unequal settlement and to give something to which to tie the superstructure. In all frame buildings bolts should be built into walls. The mud sills should be firmly bolted down and joist and studding thoroughly spiked into sills. There are many instances of frame buildings having been thrown off the foundations at corners with of course a resulting dropping of the frame which, in cases of poor framing in superstructures, caused bad wreckage.

In the case of the common forms of vertical wood underpinning, on detached piers the wood caps should be bolted to masonry, and there should be sufficient lines of vertical diagonal bracing in two directions to insure the whole building moving as one mass, as the action of an earthquake takes the form of pulling the foundations out from under the superstructure, and if the building is so built that this is not possible a great element of danger is elminated.

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*Paper read at meeting of Chapter, Los Angeles, Feb. 8, 1922.

If the common method of frame construction, that of building one story at a time, is used, the upper story should be thoroughly spiked to the story below, this again to prevent the lower story moving out from under the upper. The roof construction also should be well braced and tied to the story below.

The same amount of diagonal bracing and bridging and tying that a good builder puts in for wind bracing and general stiffening will insure the requisite stiffness to withstand an earthquake shock.

In brick construction there should be more cement used in common brickwork than is customary. One should know that bricks are wet before using and that the brickwork is well bonded and that the cement goes into the mortar. As stated above, it is the poor masonry that goes to pieces in an earthquake shock.

More care should be taken to thoroughly anchor joists to brick walls. Some builders will fairly well anchor end joists and be careless about anchoring parallel joists, forgetting that the wall needs the bracing given by the floor just as much as the floor needs building so it will not slip off the walls.

In the case of large roof spans, avoid the scissors type of truss! Be sure to get straight bottom cords to trusses and have them well bolted into walls. In the San Francisco earthquake there were some notable cases of power houses with high walls and long roof spans, with straight bottom cords, that withstood the shock splendidly. Any form of truss or roof that, under a shock, will develop a vibration of the main strut member has a tendency to push out the supporting wall.

The commonest visible evidence of damage from earthquake is in chimneys. Japan, where earthquakes are, one might say, an every-day occurrence, solves that problem largely by not building chimneys, but so much of the sentiment of home to the Anglo-Saxon is built around the fireplace that it is almost indispensable, and it is not easy to build a chimney high enough above adjoining roofs to insure draft and at the same time make it earthquake proof. If, however, we would build at least the end walls of our common chimneys 8" thick instead of 4" and build into these walls, at each corner, a ¼" vertical iron rod with an occasional bond iron running entirely around the chimney and avoid the use of too much corbelling in the tops and use a good cement mortar, we will have a chimney that will stand a stiff shock. Terra cotta flue linings tend to stiffen the chimney and reduce the danger from fire, due to cracks in the main walls, caused by an earthquake.

More care should be taken to curtail the height of street facade fire walls and in tying walls back to roofs.

More care should be taken to avoid unnecessary projection in cornices and to thoroughly tie same into supporting walls and to thoroughly support and tie in all ornamental features.

I would discourage the use of common form of hollow tile walls and partitions, I mean the form in which the only bed for mortar is the end web of the tile. If this form is used it should be reinforced.

There should be a state law that would provide and enforce a checking of plans for masonry buildings in small towns where there are no building laws. It is an unquestionable fact that the damage from earthquakes is more pronounced in such towns than in the larger cities where building is done under the supervision of a competent building department.

It is probable that the shocks of June, 1920, in Los Angeles were very nearly as severe as those of May of the same year in Inglewood, yet the damage at Inglewood was out of all proportion greater, due undoubtedly to poorly built structures, which were built on the go-as-you-please basis by contractors who perhaps did not know what really constitutes good building.

The establishment of district offices where builders from adjoining small towns would go for building permits would hold down the cost of such state supervision to a sum which, considering the danger due to present careless methods, we could well afford to pay.

In conclusion, this article is not intended as a technical treatise on the details of earthquake resistant construction, but rather, while calling attention to some of the simpler principles of such construction, is more of an urgent plea to all architects and builders to impress upon themselves the fact that earthquakes are possible anywhere and probable in many localities and to ask them to take the subject seriously and to so build as to minimize the dangers resulting from earthquakes and to remember that a good simple formula for earthquake protection is BUILD WELL!

Remodeling Old Mill-Construction Warehouse with Reinforced Concrete

An old 4-story warehouse building in Spokane, Wash., was made over from a timber mill-construction building into a modern reinforced concrete warehouse with floors designed to carry 400 lb. per square foot live working load. How this was done is described by Walter H. Wheeler, Consulting Engineer, Minneapolis, Minn., in a recent issue of Concrete.

The old walls of this building were stone and brick and were for the most part in good condition. They rested on solid rock foundation. The old story heights were 11 ft. 7 in., floor to floor, except the top story, which was about 12 ft. average height, with pitched roof. The old floors were of wood joist, wood beams, and wood posts, with wood sheathing and flooring for the surfaces.

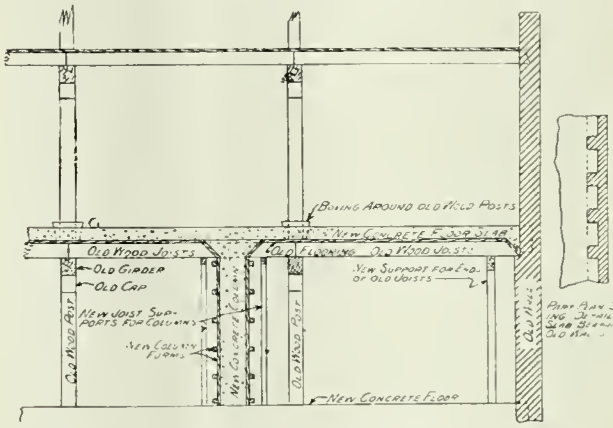

Fig. 1.—Sketch of Part Cross Section of Warehouse.

The new floors and roof are reinforced concrete, Spiral Mushroom system flat slab, with standard column capitals, and without depressions over the columns. New concrete footings were placed to receive the new columns, with dowels to the columns. The column spacing was made 19 ft. 6 in. by 18 ft. 6 in., which permitted the new columns to pass through the old wooden floors without interfering with the old posts or girders. New columns were placed against the inside face of the walls, except at the corners of the building. The slabs are notched into the old walls to give bearing of 9 in. on two sides of the building, the notches being two bricks long, with spaces one brick long between left undisturbed. On these two sides there is a concrete fillet between the slab and the inner face of the walls. On the other two sides of the building the slabs are also notched into the walls in a similar manner to tie the walls into the floor construction, but the slab load is carried by beams between columns and placed just within the walls. At the corners of the building, where there are no columns, these beams are supported on the walls. Beams were used on these two sides, because the walls were not as heavy and there were more openings in the walls, so it was considered desirable to relieve the walls of the floor load.

In executing the work, the necessary openings were made in the old floors for the column capitals, and the floor cut out where new beams are located, the new column forms and beam forms erected, and the steel laid on the top of the old wooden floor. The old floors made the forms for the new concrete floors, which were poured as usual from the bottom up to the roof. It was only necessary to make the slight alternations in the old floors above mentioned and put in the necessary new form work. Boxes were placed around the old wood posts, as shown in Fig. 1, with sloping sides to leave openings in the new slabs smaller at the bottom than at the top. After the concrete work was in place and cured, the old floors were removed from the building. From this point on to completion of the building there was nothing unusual about the work. The holes in the slabs left by the old wooden posts were filled with concrete, and the cement finish applied in the usual manner.

The lumber in the old floors was practically undamaged by the reconstruction, so that the salvage was about the same as though the building had been wrecked. The cost of forms was of course very small compared with the form work for a new building.

The success of the operation depended upon selecting the type of reinforced concrete construction, which would require the least cutting of the old floors and roof and using the old floor levels as they were. A construction which required depressions on the columns, or a beam construction, would, of course, have increased greatly the cost of the form work, and depreciated the value of the lumber for salvage. The salvage of the lumber is an important item at prices which have prevailed in recent years.

Recent Fire Tests of Loaded Timber Columns*

By THEODORE F. LAIST.

The important conclusion reached as a result of a series of tests recently carried on at the Bureau of Underwriters, 207 E. Ohio St., Chicago, may be stated briefly and in general terms as follows:

The fire endurance classification of a nominally 12-in. by 12-in. select structural long leaf Southern pine or Douglas fir column of ordinary length, may be more than doubled if the ends are adequately protected against fire. It appeared from these tests that instead of a 35-minute endurance rating, a 1¼-hour rating may safely be given providing the steel caps as ordinarily used are insulated or a concrete cap is used, thus preventing the crushing and brooming of the wood fibers under the cap and causing failure long before the sectional area of the column is otherwise reduced to a point of failure. It has, also, been shown that such adequate fire protection for the ends of timber columns in mill construction buildings may be obtained by reinforced concrete post caps such as were used in these laboratory tests. While such caps have been successfully devised for experimental purposes, so far they have not been commercially produced, nor have such tests been made upon caps supporting girder loads.

While in this series of tests no experimental work was done with steel or cast-iron caps, it is apparent that consideration of the results obtained would suggest that adequate insulation for the ends of timber columns may be obtained from the installation of fireproof materials on the exposed faces of standard steel or cast-iron post caps.

Other methods of insulating metal caps have so far not been successful for it has been determined, by actual test, that interposing insulating materials of various kinds and thickness between the metal post caps and the ends of the timber columns does not prevent failure of the columns by local end crashing, when loaded and exposed to fire.

These are the important conclusions which may be drawn from the series of tests carried on at the request of the National Lumber Manufacturers' Association. That the knowledge thus gained will have in time a far reaching effect on mill construction is obvious. The way has been pointed out for further investigation in the design of the most commercially practical cap. The concrete cap has solved the problem and there is the alternative of using a protected steel cap. The mechanical difficulties of so insulating the standard metal cap as to achieve the required result should involve no great difficulty. While the concrete caps used in the experimental work did not sustain girder loads, sufficient is known in regard to the design of structural members of concrete and the behavior of reinforced concrete under fire and similar conditions to justify the assertion that no difficulty need be anticipated in this direction. The tests, also, verified the greater superiority in fire resistance of timber construction to unprotected steel or cast-iron framing.

It may be interesting to follow the history of the development of this work and review briefly the tests which led up to these investigations.

Previous Tests of Unprotected Columns.—The circumstances which led to the tests and which eventually became the basis for the above stated conclusions, were brought about by observations made during a series of 106 fire tests of loaded columns of various materials, which were carried on during 1917 and 1918 at the Underwriters' Laboratories and conducted jointly by the Associated Factory Fire Insurance Companies, The National Board of Fire Underwriters and the Bureau of Standards.† Among this series were included six tests of timber columns, four of the columns being unprotected, the others being protected by various means; the latter are of no special interest and have no direct connection with the subject of this report. Four of the columns tested at the time were made of long leaf pine and two of Douglas fir. The post caps used were of steel of standard design. The time of failure of the unprotected timber columns varied from 35 to 50 minutes. The failures were localized in each case at the bearings with the metal caps, and occurred at the end of the column in contact with the steel or cast-iron caps, through crushing and brooming of the fibres, followed by slipping or failure of the cap. Because of such premature failure the full resistance of the columns, under conditions generally assumed in the column formulas, was not obtained. During the test of the unprotected columns, the deformation at the bearing increased rapidly after the first 20 minutes, and at the time of failure was in excess of 3 in.

In all cases the action of the steel column cap accelerated the failure of the wooden column. Incidentally it may be stated that it was found that timber columns resist severe fire exposure longer than do unprotected steel columns which has been demonstrated in many fires in buildings.

Plan of New Investigation.—The object of this investigation, conducted at the request of the National Lumber Manufacturers' Association and carried on during 1921, was to study the nature and extent of the deformation accruing at the ends of loaded timber columns in contact with metal post caps, exposed to fire, under conditions similar to those existing in the series mentioned in the previous paragraph.

A further study was made for the purpose of determining the feasibility of preventing local crushing at the ends of the column by interposing insulating materials between the metal caps and the wood of the columns. This method having been found unsatisfactory, it was determined to substitute a reinforced concrete cap of special design and finally to obtain information regarding the ultimate resistance to fire of loaded timber columns in which failure by local crushing at the ends did not occur.

The reinforced concrete caps used in these laboratory experiments were made by the Underwriters' Laboratories from the design of Mr. S. H. Engberg, Physicist, Bureau of Standards. To make the construction generally available a patent dedicated to the public was applied for and granted.

Details of the Apparatus Used in the Tests.—The equipment used in the tests was the standard equipment for fire and load tests of the Underwriters' Laboratory, comprising a carriage and traveling crane for handling the test samples, a furnace, a hydro-pneumatic for applying load, means for determining deformations and instruments for indicating temperatures.

The combustion chamber is 7 ft. square by 12 ft. high, and for purposes of observation its walls are provided with observation holes glazed with mica. Heat is furnished by means of four gas burners located at the lower corners of the combustion chamber.

The hydro-pneumatic press, used for applying load to the columns, is designed to maintain a constant load during the test and during the failure of the sample. The operating medium is water. The main piston of the press is 36 in. in diameter. The apparatus has a load capacity of 545,000 lb. and has been calibrated by the Bureau of Standards. The accuracy of loading within the range employed in the present series of tests is believed to be within 2 per cent.

The apparatus for measuring deformation, employed for the tests on wooden columns, was one by means of which the downward motion of the press piston may be indicated during the progress of the test.

For measuring temperatures, four Hoskins thermo-couples, mounted in steel pipe protecting tubes, are inserted in the furnace at various heights above the base. Measurements of temperatures, on the samples, or within the samples, are provided for by means of thermo-couples of such material and location as are adapted for the particular conditions.

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*Address delivered at the Building Officials Conference, held at Indianapolis, Ind., April 25-28.

†The results of these tests have been published in a report issued in January, 1921. "Fire Tests of Building Columns," printed by Underwriters Laboratories, 207 E. Ohio St., Chicago, Ill.

Description of Samples.—A description of the samples used in one of the tests will generally apply to all six tests. For three of the tests the columns employed were of dense grade Southern long leaf pine, nominally 12 by 12 in. in cross section and for the remaining three the columns were of Douglas fir. In every case the columns were approximately 10 ft. 10 in. long and nominally 12 by 12 in. in cross section.

The Post Cap.—The post cap especially devised for this series of tests, and to which reference has been made previously in this paper. The reinforcement was made of ¼-in. Havemeyer rods, bent by hand, and welded at all surfaces of contact. The concrete was made of 3 parts (by volume) of cement, 2 parts of Fox River sand and 4 parts of crushed limestone, which passed a ½-in. mesh. The caps were removed from the forms after about seven days and were tested after they were from 24 days to 5 months and 20 days old. The weights of the caps varied from 316 to 335 lb.

Results of Tests.—It is not possible, within the scope of this paper, to give a detailed description of each sample and the observations made during individual tests, but the following general statements may be accepted as applying with sufficient accuracy to all:

The character of the fire at the beginning of all tests was luminous and fairly well distributed, in every case the flames being in contact with all parts of the sample.

The wood members began to char immediately and the contraction of the charred material produced a checkered appearance on all exposed surfaces. In each case vertical checks appeared in the column and during several of the tests the column split vertically along the whole length of the column. The concrete cap was bright red at the conclusion of the test in each case. The edges were in part superficially calcined, the flanges slightly spalled. Hair cracks developed throughout the cap. In only one of the tests, C-4, the concrete cap showed cracking which, however, was not a primary failure of the cap but was due to the lateral thrust developed by the column at the moment of failure, neither did this condition of the cap produce or contribute to the failure of the column.

TABLE SHOWING DEFLECTION AND TIME OF FAILURE IN THE SIX SAMPLES TESTED.

No. of test.	Time in minutes.	‡Deflection in. ins.	Minutes after test started when failure occurred.	Condition of cap.	†Area of uncharred wood. Per cent.
*C-3	45	0.10	84	Slightly cracked	41
C-4	40	0.06	78	Cracked, edges	50
C-5	55	0.03	108	Spalled slightly	43
C-6	50	0.06	98	Spalled slightly	44
C-7	50	0.05	94½	Considerable spalling	43
C-8	55	0.06	112	Upper portion of each flange broken	35

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*Columns C-3, C-5, C-8 were of dense grade Southern long leaf Pine. Columns C-4, C-6, C-7 were of Douglas Fir.

†Outside of region of failure.

‡The term "deflection" is used herein to designate vertical downward movement of the upper end of the assembled sample as indicated by downward travel of the piston of the press mechanism.

Painting Lengthens Life of Steel Highway Bridges

The life of many steel highway bridges is materially shortened because of infrequent and improper painting, says the Bureau of Public Roads of the United States Department of Agriculture. Each year a considerable amount of money is spent for the replacement of rusted bridge members that would have remained sound if they had been kept painted; and more serious than the waste of money is the danger to the public due to the weakening of some hidden part which may cause the collapse of the whole bridge.

Officials of the bureau urge that all steel bridges be inspected at least once each year and repainted at the first sign of rusting. Normally repainting is required at periods of from two to five years, depending on the climate. A suitable paint should be used, and if there is uncertainty about any paint, information should be requested from the State highway department.

It is a mistake to repair without properly cleaning the metal of all dirt, rust, loose paint, and blisters. Usually the places hardest to reach are the ones that should receive the most attention.

Artistic Design of Bridges

Fundamental Principles Outlined in Address Before the Civil Engineers' Club of the University of Toronto

By CHARLES EVAN FOWLER,
Chief Engineer, Detroit-Windsor Bridge.

The use of such a title for this brief article, as is usual in similar discussions, "The Architecture of Bridges," would seem to the writer to point to a misconception of the real problem. There is as yet no architecture of bridges and it is doubtful if there ever will be any system of hard and fast rules to govern their artistic design.

There are, however, certain fundamental principles and certain elements of design which must be observed, if we are to arrive at a pleasing ensemble for any particular structure. The problem is much more simple if we are designing a stone arch bridge, or one of concrete, or one of reinforced concrete, than is the case when designing a steel span or series of such spans. However, there are certain basic principles that apply to any and every type of bridge.

Artistic Essentials.—Simplicity, harmony, symmetry and proportion must be regarded in any design that would have any pretentions to beauty or artistic effect. They are the fundamentals of true architecture or artistic design, no matter what the structure may be to which thought is to be applied in its design.

Simplicity means first a truth-telling structure, no subterfuges about the lines of stress, no covering of a concrete structure with a stone facing, no frivolous or inappropriate details, but a strict adherence to the necessary features, whether they are to carry the loads or to ornament the bridge.

Harmony is essential to a pleasing or artistic design, for without it the structure would be distasteful. Harmony not only as between substructure and the superstructure; between the various spans; between the spans and approaches; between the utilitarian features and the ornamental details, but with the surroundings as well.

Symmetry may or may not be essential to a pleasing design, although it usually is necessary if a truly artistic structure is to result. Where the bridge has great length, unsymmetrical features are not so noticeable as in a shorter one, which may all be seen at a glance. As is often true in a landscape, balance must often be secured by including an unsymmetrical feature. That is, wherein one portion of a structure, a draw span or other unbalanced feature must be included that will destroy the symmetry, something must be introduced in another portion that will restore the balance, although symmetry does not result.

Proportion is necessary, that the three preceding principles may be realized, and usually, but not always, when the economical proportions have been determined, they are pleasing. However, in many cases modifications must be made to reach the point where economy and beauty can both be satisfied. Proportion of the details employed for ornamentation is quite another thing, and to be harmonious they must also be properly proportioned.

Examples may be seen in almost every structure of the proper application of some of these principles, but more often do we find most of them flagrantly violated. The remark made by C. Shaler Smith, the dean of American bridge engineers, to one of his assistants—"Most bridges are examples of what not to do"—must be remembered by anyone who wishes to attain to high rank in his profession. It is to be feared that in most cases we feel that, "in the long run, the average sense of the many is better for the many than the best sense of any one man." There is a right and a wrong; most engineers attain neither, in the hope they are right and the fear they are wrong.

Pleasing Ensemble Vital.—We need not care whether a detail is Byzantine, Greek, Roman, Gothic, or Renaissance if it is of the proper proportion, harmonizes with the other details, with the structure, and helps in forming an entirely pleasing ensemble. The Gothic arch was Persian before it was Gothic. Our structure may be similar to a work of architecture, in that it is neo-classic, but who would say that for this reason the Rathhaus of Cologne, or the Hotel de Ville in Antwerp, are not good pieces of art?

The diagonals or latticing in a bridge are sometimes unpleasing and at other times in some other structure, not unpleasing. They probably originated with the savage, who used vines or fibre to form diagonals for his primitive structures. The farmer of today still uses ropes or wire for similar purposes, but as yet diagonal bridge members, nor yet garden trellis, have been accorded a niche among architectural styles. The engineer, for some scores of years, has calculated his diagonals, and used them in his design because he believed they were necessary, no matter how incongruous they appeared. Now we know how to provide for secondary stresses and can often omit the diagonals whenever a more pleasing structure will result.

Ornamentation.—The curved lines of the suspension bridge and of the arch are inherently beautified, and simplicity is best illustrated in its pleasantest features in bridges of this type with no decorations or embellishments of any kind. However, we must not overlook the fact that even a chaste design may be much improved in appearance by the use or addition of appropriate and harmonious details or decorations. The suspension bridge seems sadly designed where the towers are not properly completed by a parapet or attic story for those of stone, and perhaps crestings for those of steel. The arch is made more beautiful by molded work in the arch ring, by the use of appropriate medallions at the key stone, by the careful embellishment of the spandrels or spandrel arches, and lastly by the use of well designed and ornamented parapets and parapet railings.

Harmony is best exhibited where no part of a structure or of its decorations seem to be extraneous, and where the structure harmonizes with its surroundings. This latter feature is illustrated by the harmony of the battlemented towers of the Conway suspension bridge and the Conway tubular bridge, with Conway castle; by the harmony of the mediaeval towers of the London Tower Bridge with the Tower of London; and by the harmony of the stone towers of the old Brooklyn bridge with the high buildings of New York City, although this is but a happy accident, as the buildings were the later development.

Symmetry.—Symmetry in its simplest form is where one-half of the structure is exactly like the other half, where one approach is like the one at the other end of the bridge. That is where the structure is perfectly balanced in the simplest manner. The most pleasing design is where the center of the bridge is at the center of the middle span, or it may be stated as a fundamental principle that an artistic bridge must have an unequal number of spans—one, three, five, or seven in number; but beyond seven spans the eye does not so readily grasp the whole and seek for an opening instead of a pier at the center. Likewise the spandrel arches of an arch bridge must be three, five, or seven in each half of the span, or where they extend across the key stone, an unequal number for the whole span.

Proportion is more nearly reached when the whole structure is most pleasing to the trained eye, and the truth most closely adhered to in every part of the structure and in every detail. The use of too great a sag in a suspension bridge, or of too great a rise in an arch bridge dwarfs the apparent length of such a span. That is, too great for appearance, even if not too great for economy.

Careful Study Needed. We must remember that there is nothing really in common between the architecture of buildings and the artistic design of bridges. The lack of any attempt at artistic design in the Williamsburg suspension bridge is deplorable; the failure to complete the towers of the Brooklyn bridge is deplorable; the attempt at an artistic design for the Manhattan Bridge produced a structure which is only not unpleasing, but in the Hell Gate arch we have a structure which is of great simplicity, of real harmony, of true symmetry, and perfect in proportion. It is not often given to man or to the engineer, to attain nearly to perfection, seldom more than once; but by careful study and thought we can obviate very many flagrant violations of the artistic in the design of our bridge structures.

Fabricating Shop Contracts in March.—The records of the Bridge Builders & Structural Society, from reports collected by its secretary, show that during the month of March, 1922, 139,300 tons of fabricated structural steel was contracted for throughout the United States, equivalent to 77 per cent of the entire capacity of the bridge and structural shops of the country.

25 Years Progress in the Standardization of Testing Methods and Specifications for Engineering Materials

Address of C. D. Young, President American Society for Testing Materials at the 25th Annual Convention of the Society, Atlantic City, June 24-30

On June 17, 1898, what is now known as the American Society for Testing Materials had its inception in an organization formed by the American members of the then existing International Association for Testing Materials. The object of the new organization was to bring together as many as possible of those interested in the subject of materials of engineering, to simplify the work of the then existing International Association, and to render its work more efficient. One of its main objectives was to harmonize and standardize specifications for materials. The courageous group who formed this organization found progress along this line very difficult. One of the principal handicaps which confronted them was the lack of appreciation of the benefits of standardization, uniformity of the methods of testing and a common nomenclature. For this reason consumers and producers alike hesitated to engage in the preparation of any standards which might, in their judgment, tend to restrict or interfere with the standards which had theretofore or might thereafter be established or recommended by engineers or manufacturers.

American Society Organized in 1902.—During the next four years but little was accomplished to carry out the paramount objects of the association, and had it not been for the personal pride of its founders and their praiseworthy determination to carry out those objects, the society might have failed of its purpose and passed into the realm of innocuous desuetude many years ago. At that time many of the members felt that this association could succeed only as an independent American institution and not as a body subordinate to an International Association. This feeling grew until 1902, when it was expressed in the incorporation and organization of the American Society for Testing Materials. From that time on its membership grew at a steadily increasing rate, and this growth has continued from that time to this with a remarkable uniformity, so that at present more than one-fourth of its members are actively devoting themselves to committee work, and many of those not so situated as to be able to give the time required for such work are contributing through papers to the advancement and knowledge of engineering materials and approved methods for testing them. If I were asked what is the most characteristic feature of the society, I would answer that it is the independence of its members from preconceived notions and arbitrary standards. This is conclusively shown by the fact that it did not justify its existence by its growth until after it had freed itself from the limitations placed upon it by the old International Association, which tended to restrain its scope to methods of testing and to academic discussions of what a specification should be, instead of permitting the greatest freedom in the establishment of American standards of testing.

Not until after the society had become autonomous was it possible to prepare standard methods of testing through collaboration and research work nor to adopt acceptable standard specifications. The untrammeled initiative of the members has been the guiding spirit of the society for the last 20 years, and finds its natural expression in the work of our widely diversified standing committees. Through regulations applicable to the needs of each committee, the form of management is unique as compared with that of other engineering societies, because it permits the freest possible expression of the views of all the members, each of whom has an equal voice in the work brought formally to the attention of the society for mass or group adoption. This method of conducting the business of the society gives to each producer, consumer or independent engineer a fair chance to speak and be heard and to present to committees of each group all angles and phases of the problems to be considered.

Society Becomes Authoritative Body on Materials Engi-

neering.—As the society became established as an independent entity, prejudice against its work gradually disappeared until it had no rival in its chosen field. At first there was none so poor as to do it reverence; but soon there was none to challenge its supremacy. Since the establishment by it of standardized methods and specifications, increasing recognition has been given it as the authoritative body not only in a few, but on all, subjects relating to materials engineering. Such great strides have been made that the society has produced standards covering nearly all of the important materials generally used in engineering construction. These standards, together with those which are now contemplated and are in course of development, will, when completed, afford to the engineer the necessary guides in engineering practices. In the preparation of these standards, the fullest coöperation has been obtained from manufacturers and producers, and the standardization thereby effected has enabled the buyer and seller to speak the same language. In overcoming the prejudice against standardization, the manufacturer has learned that it is possible for him to produce a far better quality of product, and at the same time greatly reduce his expenses through mass production. This lower cost makes it possible not only to offer to the public better materials at lower unit prices, but also to maintain at the same time higher wages for labor.

American standards of quality, having forced recognition throughout the world, have stabilized production and employment through the broadening effect of increased markets, and have made it safe for manufacturers to accumulate stocks during dull periods, when, without such standards, such a policy would have been extremely hazardous not only to the manufacturer but also to the general public.

Standardization Permits Concentration of Skill Upon Design.—Although standardization restricts the varieties for selection, it permits concentration of thought and skill upon design, so that the product may be more economically and efficiently handled. It also reduces the maintenance cost of the finished structure by simplifying the stocks necessary for their maintenance. These well-established standards have established that factor of safety which is essential for the engineer in making the finished product. Moreover the care which is exercised by the committees in the preparation of their standards gives full assurance to the public that the materials purchased and inspected in accordance with the recommendations of the society will result in furnishing the best that can be produced, at the lowest possible cost, and at the same time will afford all safety necessary to the public welfare.

All Views and Interests Represented in the Committees.—In the formation of the committees great care is exercised in making the selections so that all views and interests will be represented by the personnel composing the committees, because long experience has demonstrated the fact that with a committee not wholly representative of the industry involved in the standard under consideration it is impossible for that standard to win general recognition.

Furthermore, even after a truly representative committee, selected from the fields of engineering, research and manufacture has reached an agreement, experience has taught us that any work offered for acceptance as a standard cannot be ultimately adopted until all of the interests involved in the problem have adjusted their ideas to the common standard, and have unanimously accepted the mosaic thus produced. How often have we seen at the annual meetings standards and methods fail of adoption because they have not had the unanimous support of all the interests involved! And how frequently has it occurred that an objection voiced at first only by one of the members has been sufficient after discussion to cause a recommendation to be referred back to the committee for further consideration! Is it not apparent, therefore, that the secret of the success of such standards as have been finally adopted as a matter of record by the society is due to such thorough consideration and unanimous approval? If, on the other hand, either in a committee, or at an annual meeting, objection is made on the ground that the adoption of the recommended standard would prevent some particular manufacturer from marketing a special article, or some engineer from gaining advantage through special design or otherwise, seldom has such an objection been supported, for as soon as its true significance has been revealed the standard recommended by the committee is supported by the membership at large. And this experience, frequently repeated, shows why our standards are being so frequently endorsed and generally used.

Standards Adopted by Other Technical Societies.—Other technical societies and governmental agencies, recognizing the worth of our procedure and standards, are looking more and more to this body as the authority on standards of materials, and for assistance in preparing specifications, nomenclature and methods of testing. Therefore we point with just pride to the abundant evidence that when the allied engineering associations desire to incorporate such specifications as a portion of their work, they adopt ours. As conclusive evidence of this fact we find our standard materials specifications in the Boiler Code of the American Society of Mechanical Engineers, our joint work on cement in the American Society of Civil Engineers, and our standards covering the quality of and tests for certain electrical materials in the standards of the American Institute of Electrical Engineers. More recently the American Engineering Standards Committee has named the society as sponsor for six standardization projects and has adopted as American Standards or Tentative American Standards fourteen specifications promulgated by us. The United States Department of Commerce, recognizing the value of the work of this society, has translated and broadcasted through its various consulates sixty-one of our standards translated into Spanish and French, and the translation is now contemplated of about forty of them into Portuguese for use in Brazil. The leading manufacturers of the country are offering as their recommended practice the standards of our society, and it is with pleasure we observe that in the recently "Recommended Minimum Requirements for Small House Construction" tentatively prepared by the Building Code Committee of the Department of Commerce, the standards of the society are offered wherever specifications for materials are mentioned. In the whole domain of science practically applied, what society can point to so many expressions of the unqualified approval of its accomplishments?

Activities of Some of the Committees.—It is impossible to present anything like a complete review of the activities of our committees during the past year. They are too voluminous and too diversified in character. It seems appropriate, however, that, referring at random to the activities of our committees, I should point out to you a few of those which, directly or indirectly, are of especial interest to the general public. This list is not complete, for, indirectly at least, all of our work affects American economic life. It is worthy of note, however, that Committee A-1 on Steel, in coöperation with the American Railway Association, has completed a study of specifications covering castings for railways, which affect the safety of passengers and afford protection to merchandise. This is a distinct advance in the requirements for such castings. Our Committee A-3 has been actively engaged in producing a specification for better cast-iron wheels, so essential to the safety of transportation, and our Committee on Corrosion of Iron and Steel, through its painstaking and elaborate physical tests, will, upon the completion of its work, establish facts which will aid the engineer in his selection of grades that will increase the wearing quality of exposed iron and steel. Committee C-1 on Cement is planning to continue research work and a study of cements embracing not only methods of tests but also the effect that other admixtures, used with cements, have upon the cement when made into concrete.

Committee C-2, engaged in the study of reinforced concrete, will recommend a practice on a matter which is of great public interest, in that it affects the safety of concrete buildings. This recommendation is an endeavor on the part of our committee to present to the public a recommended practice for strict observance of the proper inspection of concrete and reinforced concrete structures.

Our Drain Tile Committee, in cooperation with other agencies, is conducting an extensive investigation to determine the effect of acids and alkali solutions on concrete drain tile. The result of this investigation will, no doubt, have a marked effect upon drainage construction, and, through cooperative action with the U. S. Department of Agriculture, will result in very great benefit to the American farmer.

Committee D-1 through its study on methods of the application of paint by spraying and certain tests of anti-fouling paint for use on ship bottoms, is making a valuable contribtion to the subject of commercial economics. If, through its work, the time now lost through dry docking and cleaning of ships is materially reduced, the economic gain to all is obvious.

Our committees on Petroleum Products and Lubricants (D-2), as well as on Road and Paving Materials (D-4), are working on the first essential step before general standardization can be agreed upon, that is, methods of testing the products of such groups. Committee D-12 is making excellent progress in the standardization of methods which will facilitate the preparation of specifications for gasoline, fuel oil and other petroleum products of daily use in almost every family. And likewise Committee D-4 is engaged in the important work of standardizing the methods of testing road materials, which will be of great assistance in the road construction program of this country; and it should be a matter of pride to our members to know that the various state highway departments are looking to this society for standardized methods of test covering materials necessary for their use in highway construction. The progress of this committee is particularly gratifying in view of the marked prejudices which must of necessity be eliminated in order to work out methods of tests and specifications which will prove universally acceptable.

The subjects of study which I have brought to your attention will indicate how closely they affect the average man on the street, for, although he may not feel a personal interest in the technical details, it must be apparent to him that practically all of the work of the members of this society, both directly and indirectly, affect him in a marked degree, in that our society, through its efforts to advance the knowledge of engineering materials, and to establish proper methods of testing and correct make-ups of specifications, is making rapid strides in the improvement of our economic life in ways too numerous to mention.

This society does not seek to monopolize all of the field of engineering materials, because our fixed policy has been, as expressed in our regulations, not to go beyond materials nor to invade the engineers' field of design, but through cooperative action to give the benefit of the knowledge of our members to the general public.

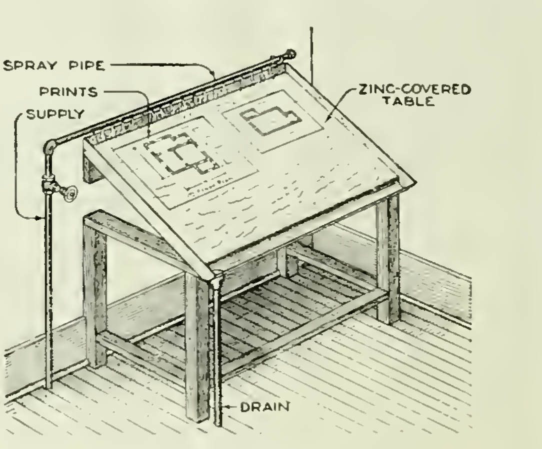
With other societies we are actively engaged in a study of improvements in, and specifications for, insulated wire and cables, and the preparation of standards for concrete culvert pipe. Through joint committee action, we are also working upon specifications for concrete and reinforced concrete. This work has taken on a far reaching and important aspect, in that the previous work of the committee is now being reviewed, and tests of the practical merit of the proposed specifications are being actively carried out in the larger cities of the country on important construction work, for the purpose of ascertaining the desirablity of following these recommendations as standard practice, before determining whether or not they are complete and economically correct.

Your Executive Body, through its standing Committee on Inter-Society Relations, is in cooperative contact with all material engineering agencies of America, and is affording them a knowledge of materials together with every assistance possible.

Standards Must Be Revised from Time to Time.—As our knowledge increases, it is very important that revisions of our adopted standards be made from time to time, for if no recognition be accorded to the increased scientific knowledge, the introduction of known materials applied to new devices, or of new products to old uses, stagnation in the work of our society would result, and, with the demand for increased knowledge of materials in other allied engineering societies, our position would soon be usurped by them. We must, however, look with caution upon each proposed modification of standards and methods, and determine beyond doubt that suggested changes are based upon practical knowledge, born of the experience of those who are best qualified to pass upon the changes proposed. It goes without saying that the necessity for modification outweighs the desirability for maintaining any given standard, proper consideration being given at all times to the disturbing effect which such proposed changes may have upon production processes essential to economic output. Here again our Society has seen the effect of the personal equation applied to some of our country's largest industries, in that the members of our Society who are connected with such industries, through round table discussion on some vital point, come to a common agreement that a better product can be specified, notwithstanding the effect which such changes may have on their processes of production. Thus a new standard may be accepted by the industry, and, without delay or friction, a better quality of product furnished to the general public for its safety and economic gain. In this way the purpose of our founders, that our Society should afford a meeting ground for manufacturers, engineers and consumers, in establishing standards of methods of testing and unification of specifications, may be realized in greater measure than was thought possible a quarter of a century ago when prejudices against such unification were so strongly entrenched.

An Improved Blueprint Washer

A blue-print washer that uses only clean water to develop the exposed prints and eliminates the need of using trays and sinks is described by B. Francis Dashiell in Popular Mechanics. With this arrangement the washing is done entirely by a flow of clean water over the print. An inclined table, which is built in any convenient location, is provided with raised sides and a trough at the bottom for carrying off the excess water, the whole being covered with sheet zinc or lead. A water pipe, which is drilled with a series of small holes, is arranged parallel with the top of the table so that there will be a uniform flow of water over the surface of the prints.



Blueprint Washer.

Tests of 4-Inch Brick Partition Walls

In a paper read at the Building Officials Conference, Indianapolis, William Carver, architect of the Common Brick Manufacturers' Association, advocated 4-in. brick walls for both bearing and non-bearing partitions.

He stated, that such walls are considered standard construction in Europe, that in England more than 90 per cent of all houses erected are built with 4-in. interior bearing partitions, and that 2½-in. partitions, built of brick laid on edge, are extensively used there for non-bearing purposes. Some recent tests made by an English building materials research committee were cited by Mr. Carver to show the strength of such construction.

The tests were made on 4-in. and 2⅝-in. walls, and included tests of pillars 14 in. wide and 42-in. lengths of wall, both 8½ ft. high, the pillars being tested under vertical load only and the wider sections under a combination of vertical load and horizontal pull at mid-height. The ultimate strength of the 14-in. pillars was found to be about two-thirds of the crushing strength of 9x9-in. cubes, ranging from 330 to 1,040 lb. per square inch for the pillars as compared with 720 to 1,530 lb. per square inch for the cubes. In the case of the 42-in. walls under a load generally of 3½ tons, a horizontal pull of 375 to 895 lb. at mid-height was required to break the wall. The low result in each case was found for a 4½-in. wall laid up in lime mortar. The 2⅝-in. wall, laid up in 1:3 cement mortar, gave results barely inferior to those found for a 4½-in. wall, namely, 1,040 lb. per square inch crushing strength on the 14-in. pillar, and 553 lb. horizontal pull required to break the 42-in section of wall under 3½ ton load.

Index Numbers of Wholesale Prices Jan., 1913, to July, 1922

The accompanying tabulation shows the revised index numbers of wholesale prices by groups of commodities as computed by the U. S. Bureau of Labor Statistics. Revised index numbers for each year from 1890 to 1913 are now in preparation by the Bureau, and will be published in this column as soon as they are available.

The group of miscellaneous commodities includes such important articles as leather, cottonseed meal, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, starch, tobacco, Manila hemp, sisal and wood pulp. The commodities, composing the other groups, are as indicated by the titles.

The new index numbers and the following explanations are from Bureau of Labor Statistics, Form 1531:

The weighting of the prices used in constructing the index numbers for the different groups of commodities by the new 1919 census figures of production, instead of the 1909 data used in preceding reports, conforms to the plan contemplated by the Bureau at the inception of its weighted index number system in 1914 of revising the weighting factors every ten years as new census information should become available. All computations have been carried back to 1913 in order to insure comparability of the figures and also to provide a pre-war standard for measuring wholesale price changes.

The following table gives the revised index numbers for the several commodity groups from January, 1913, to the latest month for which complete information is available. For comparison with the new series, the old general index of all commodities is shown in the last column of the table. Publication of the old series was suspended with the April, 1922, figures.

REVISED INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES AND BY MONTHS, 1913 TO 1922 (1913 EQUALS 100).

										All commodities.	
	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	New index.	Old index.
1913	100	100	100	100	100	100	100	100	100	100	100
Jan.	98	99	99	100	107	101	100	100	106	100	100
Feb.	98	98	100	101	105	102	101	100	105	100	100
Mar.	98	98	100	101	105	103	101	100	103	100	99
Apr.	99	98	100	98	104	103	101	100	100	100	98
May	97	97	100	98	103	103	100	100	98	99	98
June	98	99	100	98	101	102	100	100	100	99	100
July	99	101	100	99	98	99	100	100	100	100	100
Aug	100	102	100	101	98	99	100	100	98	100	101
Sept.	103	103	101	101	98	99	100	100	100	102	102
Oct.	103	102	101	102	97	98	100	101	98	101	101
Nov.	103	103	101	102	94	97	100	100	97	100	101
Dec.	103	101	100	99	89	96	98	100	96	99	99
1914	103	102	98	93	85	92	101	100	95	98	100
Jan.	103	101	99	99	88	93	98	100	94	98	100
Feb.	103	100	99	99	89	94	98	100	96	99	99
Mar.	102	98	99	100	89	94	98	100	98	98	99
Apr.	102	95	99	98	88	93	97	100	98	98	98
May	101	96	99	95	85	93	97	100	99	97	98
June	101	97	99	91	84	93	96	100	95	97	99
July	103	99	99	91	83	92	95	100	93	97	100
Aug.	106	109	99	89	84	93	96	100	94	101	103
Sept.	106	111	97	89	86	92	109	100	96	102	104
Oct.	101	106	96	88	83	90	108	100	92	97	99
Nov.	102	106	94	88	80	88	107	100	91	97	98
Dec.	101	105	94	88	81	88	107	100	96	97	98
1915	104	105	98	88	99	94	134	100	95	101	101
Jan.	104	106	94	87	82	88	108	99	99	98	99
Feb.	105	108	95	86	86	89	116	99	93	99	101
Mar.	104	106	95	84	88	90	118	99	93	99	99
Apr	104	105	96	82	90	90	118	99	93	99	100
May	105	105	96	82	96	93	116	100	93	100	101
June	101	102	96	81	102	93	123	100	93	99	99
July	104	164	96	81	106	94	130	100	94	100	101
Aug	103	102	97	85	103	93	136	100	93	100	100
Sept.	101	99	99	91	104	94	143	100	92	100	99
Oct.	106	102	101	94	105	98	151	100	93	102	101
Nov.	104	106	105	98	110	101	165	100	95	104	103
Dec.	105	108	107	103	122	104	179	101	100	108	106
1916	123	121	127	126	162	120	181	106	121	127	124
Jan.	110	109	110	113	133	110	184	103	110	113	110
Feb.	110	110	114	115	142	113	204	103	105	115	112
Mar.	111	112	117	119	156	118	206	104	108	119	114
Apr.	113	114	118	120	164	120	200	104	110	121	117
May	115	115	120	120	168	121	193	105	114	122	118
June	114	115	122	122	164	120	191	105	120	123	119
July	117	117	125	121	158	120	175	107	120	123	119
Aug.	125	122	128	116	167	120	157	107	121	126	123
Sept.	131	126	130	120	160	121	158	107	124	130	128
Oct.	136	134	137	128	164	124	164	109	132	136	134
Nov.	147	141	147	155	174	126	167	111	139	146	144
Dec.	146	137	154	163	199	132	172	111	147	149	146
1917	190	167	175	169	231	157	202	125	148	177	176
Jan.	152	140	158	171	198	138	173	118	149	153	151
Feb.	157	145	157	178	204	140	173	119	150	157	156
Mar.	166	148	158	174	218	144	181	120	151	162	161
Apr.	184	164	164	164	230	155	186	121	153	173	172
May	196	175	167	178	240	159	194	121	151	183	182
June	195	171	174	183	267	169	195	123	153	185	185
July	196	169	181	176	292	168	205	129	153	188	186
Aug.	202	175	186	167	282	167	211	129	150	180	185
Sept.	202	176	185	160	260	167	223	130	147	187	183
Oct.	207	180	185	153	207	156	231	130	142	183	181
Nov.	212	181	191	161	183	156	223	131	140	183	183
Dec.	207	181	195	163	183	158	228	133	146	182	182
1918	218	188	228	170	187	172	215	153	156	194	196
Jan.	211	182	201	164	183	161	223	137	145	184	185
Feb.	211	183	205	164	184	161	227	138	145	186	186
Mar.	211	179	211	165	184	164	229	140	147	187	187
Apr.	213	181	220	166	181	169	228	144	152	190	190
May	209	180	226	169	185	170	222	146	155	190	190
June	210	180	233	169	184	172	205	152	160	191	193
July	217	185	238	175	189	177	209	159	159	196	198
Aug.	227	189	239	175	190	179	212	161	160	200	202
Sept	234	195	245	176	190	179	210	163	161	204	207
Oct.	225	198	245	176	192	177	211	164	163	202	204
Nov.	225	204	241	179	191	177	209	164	164	203	206
Dec.	227	206	233	179	187	177	194	163	163	202	206
1919	231	207	253	181	162	201	169	184	175	206	212
Jan.	224	203	220	178	175	176	181	167	166	199	203
Feb.	216	194	210	178	170	173	169	165	163	193	197
Mar.	224	199	203	178	163	171	162	164	161	196	201
Apr.	230	205	205	177	153	169	160	167	160	199	203
May	234	210	216	178	153	173	161	168	161	202	207
June	226	204	243	180	154	189	162	180	167	203	207
July	241	210	262	181	160	209	167	183	177	212	218
Aug.	242	214	276	184	162	226	170	188	187	216	226
Sept.	225	205	283	188	161	229	170	190	189	210	220
Oct.	227	205	291	189	162	229	173	194	187	211	223
Nov.	237	210	304	188	164	232	176	217	189	217	230
Dec.	242	220	317	189	168	248	182	222	189	223	238
1920	218	220	295	241	192	264	200	254	196	226	243
Jan.	247	231	339	194	175	274	189	239	194	233	248
Feb.	237	222	346	199	190	293	195	242	197	232	249
Mar.	237	220	344	208	197	297	205	242	200	234	253
Apr.	243	238	336	231	203	300	210	242	206	245	265
May	241	248	328	239	202	293	213	247	208	247	272
June	237	243	314	250	200	275	212	248	205	243	269
July	233	238	300	259	202	269	212	275	203	241	262
Aug.	218	221	286	269	202	265	209	274	199	231	250
Sept.	210	215	266	281	200	255	205	273	195	226	242
Oct.	187	201	245	280	191	240	198	271	188	211	225
Nov.	173	190	226	264	176	215	181	260	179	196	207
Dec.	152	170	215	254	160	204	164	242	166	179	189
1921	124	144	180	199	129	165	136	195	128	147	153
Jan.	143	162	196	247	153	192	153	217	154	170	177
Feb.	133	151	188	225	147	180	149	217	147	160	167
Mar.	127	151	183	212	140	173	143	216	139	155	162
Apr.	117	144	176	205	138	167	135	216	130	148	154
May	118	139	173	200	138	165	134	209	126	145	151
June	114	137	172	191	133	163	133	196	125	142	148
July	119	141	172	186	124	160	129	180	123	141	148
Aug.	123	146	171	184	117	156	129	179	119	142	152
Sept.	124	142	178	181	116	156	131	179	118	141	162
Oct.	124	140	180	189	116	159	131	180	118	142	150
Nov.	121	139	180	197	114	163	129	178	119	141	149
Dec	120	136	180	199	113	158	127	178	121	140	149
1922											
Jan.	122	131	176	195	112	157	124	178	117	138	148
Feb	131	135	174	191	110	156	123	177	117	141	151
Mar.	130	137	172	191	109	155	125	175	117	142	162
Apr.	129	137	171	194	113	156	124	175	116	143	152
May	132	138	175	216	119	160	122	176	116	148	...
June	131	140	179	225	120	167	122	176	114	150	...
July	135	142	180	254	121	170	121	173	114	155	...

Engineers' and Contractors' Trip to South America

An excursion for combined business and pleasure purposes is being promoted by The Earth Mover, Aurora, Ill.; Charles P. Burton, manager-editor. If the plans are carried out as now proposed members of the party will have full opportunity to dispose of their time as may appear most desirable; but the various stops are to be arranged primarily to afford the best business opportunities.

The party would probably leave New York Dec. 2. An ideal trip would be by way of the Panama Canal, down the west coast, stopping at the important cities on that coast, crossing over the wonderful Andes Mountains at Valparaiso to Buenos Aires, and returning by the east coast, stopping at the larger cities, Montevideo, Santos, Rio de Janeiro, etc. Such a trip would take about three months, at a time of the year when construction work in the United States and Canada will be at a standstill or at low ebb, and contractors will have more or less leisure on their hands. It will be summer time in South America, the best time for seeing that country.

The round-trip costs, everything first class including transportation, hotel, and traveling expenses, will be approximately $2,000. Members of the party are invited to bring their families.

Suggestions are invited. All communications should be sent to Mr. Burton at the address given above.

American Construction Council

The organization of the American Construction Council is the culmination of the movement begun during the War for the proper recognition of construction as one of the nation's major industries. It offers a constructive response to the demand for the united expression of the best thought and power of the industry on common problems, at a time when public confidence in the industry has been sorely shaken. It is not, however, an eleventh hour attempt to reform construction. Without doubt the movement to bring every element of the industry together, received added impetus from the exposures which have been made in New York and Chicago, but the movement itself was well under way long before these investigations were even planned. The significant point at this time is that at last a national council representing every element, including the public, and heartily supported by the leaders in every element has been successfully and auspiciously launched.

No one who attended the two days' session in Washington, June 19 and 20, could fail to note the high character and purpose of the hundred and fifty men who met to organize the Council. They were representative men. They were big men—both in vision and in accomplishments. Over fifty of the leading national associations interested in construction were officially represented. A score of others were represented by observers.

The thoughts expressed by Secretary Hoover, Willis H. Booth, Walter Gordon Merritt, and F. M. Feiker in their addresses outlining the work which such an organization could accomplish for the construction industry, were not mere generalities uttered in a desire to make pleasing speeches. They were concrete, specific recommendations born of the actual need for action, as they know it exists. The responses made by leaders in each of the eleven groups which go to make up the Council, indicate that they too were speaking from experience and not alone in ideals.

Industry—and especially the construction industry, has developed to a point where individualism no longer works, where even united action on the part of separate units is no longer satisfactory. It has passed through the pioneer stage of individual effort; it has been going through the phases of community growth in various groups; it is emerging into a great confederation which shall act for the good of all. Who shall say that from this beginning may not be written a Constitution which shall form the basis for an industrial state, coordinate with and equal to the political state founded by our fathers a century and a quarter ago? Their need was then for organization which should meet problems mainly social and agricultural; the past century has added a vast industrial problem, and we are just beginning to meet it. It should be with pride that the construction industry is helping to blaze the way.

The press has sought a parallel in the election of Mr. Roosevelt as President of the Council, with the appointment of Judge Landis as baseball arbiter and Will Hays as mentor of the moving picture industry. This is not so. Mr. Roosevelt is neither arbiter nor mentor; he is a representative of one of the groups interested in the construction industry and as such is cooperating to bring the best of each together for the good of all. Again, neither baseball nor the movies has developed any such fundamental basis of organization as that on which the American Construction Council is founded. The appointments of Judge Landis and Will Hays are the projection of two able and interesting personalities; the organization of the American Construction Council is a part of the movement of industry throughout the world to become an articulate factor in society and government. It is significant of American institutions and traditions that this movement is being expressed from within industry itself and not being imposed upon it from without. It will have more difficulty getting started, but it will be stronger and more nearly right in the end.

For general contractors, the Council offers a means of securing united action on problems which we are just beginning to realize cannot be solved with our own resources either in man or money. The development of a code of ethics, the gathering of adequate statistics and information and the investigation of a score of questions such as the apprenticeship problem, a standard building code, reduction of seasonal unemployment, the establishment of open wholesale markets, the adoption of standard contract forms, etc., are all possible only through the cooperation of other elements in the industry. The Council offers a ready means of securing that cooperation.

It is also of significance to general contractors and the part they are taking in the industry that the success of this first organization meeting was due in great part to the efforts of General Marshall, who acted as chairman of the Temporary Operating Committee; E. W. Reaugh, who proposed the resolution calling for the conferences preliminary to the meeting and N. F. Hoggson, F. L. Cranford and D. A. Garber, all members of the Associated General Contractors.

The American Construction Council is a practical, far-sighted accomplishment. It should have the support of every general contractor who can see beyond the confines of his own small town.—Editorial in the July issue of The Constructor, official organ of the Associated General Contractors of America.

Fire Prevention Exposition in October

Manufacturers of fire-resistive materials and of fire-fighting and retarding apparatus, for the first time, will have the opportunity of taking part in a Fire Prevention Exposition to be held Oct. 2 to 7 at the Twenty-second Regiment Armory, New York City, where will be shown, by exhibit and demonstration, what a vital part in the fight against the great annual fire loss is played by fire-safe materials and apparatus.

The Exposition originated with the Fire Prevention Committee of the National Association of Insurance Agents as part of its program of fire prevention activities. It has been endorsed by the National Fire Protection Association, the National Association of Credit Men, by President Frank G. Reynolds of the International Association of Fire Engineers, the National Board of Fire Underwriters and other associations.

At the present rate of burning, property worth $1,300,000 is being destroyed each day. This is a financial burden which is borne by business men, for the fire insurance companies, contrary to general belief, do not bear this loss—they simply pay out $1,300,000 each day that has been paid in to them in premiums by the public.

Already requests for space are reaching the Exposition Committee and it is expected that every foot of available space will be taken.

A. E. MacKinnon of 405 Lexington Ave., New York, is chairman of the Exposition Committee; James T. Catlin, Jr., Danville, Va., chairman of the Fire Prevention Committee of the National Association of Insurance Agents, and Frank W. Lawson, American Building, Baltimore, Regional Chairman of the Fire Prevention Committee, with Mr. MacKinnon, compose the Exposition Committee.

Truscon Sash in M. K. & T. Freight House

The account of the new fireproof freight house of the Missouri, Kansas & Texas Ry. at Dallas, Texas, on page 94 of our issue of July 26 was in error in stating that Fenestra sash was used in the transoms. The sash used on this job was Truscon, and we take this opportunity of calling the error to the attention of our readers.

A. A. E. Employment Service Development.—The Board of Directors of the American Association of Engineers at its meeting July 7-8, in addition to outlining the major work which the association would undertake, decided to concentrate the association's efforts, so far as they related to the immediate individual concern of the membership, to the establishment of an effective employment service. It was the opinion of the board that, through the opportunity that would be afforded by the organization of chapters as authorized under the revised constitution there could be established at a number of points throughout the country an employment service under the general supervision of National Headquarters that would be the beginning of one of the most effective and valuable services that the association has ever undertaken for its membership. This is an enlargement of the employment service which has been rendered by the American Association of Engineers for several years past. With enlarged financial resources it will be possible to maintain a complete and up-to-date directory of technical specialists.

Foreign Engineering Review Quarterly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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The True Economics of Railway Electrification

Editorial in The Railway Engineer, London.

Reference has on several occasions been made to the fact that advocates of railway electrification on economic grounds, and those who maintain that present methods under steam traction are equally efficient, cannot agree upon acceptable bases for comparison. An American contemporary recently attempted to define the fuel consumption basis, this being one of the principal grounds for the alleged "extravagant" claims made on behalf of electrification. The application is to proposals for super-power electrification schemes for American railways, and to an estimate that by electric operation no less than 57.6 per cent. could be saved per unit of work done. It is pointed out, however, that while an equivalent coal rate of 3.18 pounds per kilowatt hour is claimed as the output of the electric locomotive, the coal consumption of the steam locomotive is assumed to be 7.5 pounds per kilowatt hour, a figure which is much too high, even for relatively out-of-date locomotives operating under unfavorable conditions.

It is suggested that if the method used in computing equivalent coal consumption under electric operation is applied to the steam locomotive, the result is quite different. Our contemporary suggests that 4.14 pounds per kilowatt hour, after allowing for standby losses, firing up, etc., would be a more equitable figure, though this would reduce the estimated saving due to electrification to 23 per cent. The whole question is admittedly a complicated one, for in addition to uncertain bases of comparison, the steam locomotive has to carry out a great deal of miscellaneous work, some of which, at least, is hardly likely to be given to the electric locomotive. It would appear, in fact, that while electrification has much to commend it where traffic is suited to its characteristics, it will require the traffic to be adapted to it to a degree which does not apply in the case of the steam locomotive, though it is the miscellaneous and incidental duties and the share taken in work for which electric traction would hardly be suggested that lower its standard of average performance.

This part of the question depends on whether traffic as a whole or on particular sections can be adapted and re-organized so as to enable the full value of electrification to be realized, rather than direct comparison between the unit performances of individual electric or steam locomotives. Naturally, electrical engineers emphasize the direct fuel economies which they can realize; but the practical efficiency of the modern steam locomotive must also be given due weight, and it will not help either school of thought to advance extravagant claims or to depreciate those of the opposite party. So much for fuel economies, but what is even more important in many cases is the remarkable saving which results from the lower cost of maintenance and repairs, about a quarter to one-third of steam costs, and also the very much larger number of hours per day and per year during which the electric locomotive can be in service. In certain cases, the economies far outweigh the fuel economies.

Inadequate Salaries to Municipal Engineers

Editorial in Municipal Engineering and The Sanitary Record, London.

We congratulated only last week the Society of Medical Officers of Health and the British Medical Association in blacklisting the Manchester Corporation until they have agreed to offer a salary higher than £1500 for a Medical Officer of Health for that city, and we ventured to ask whether the time would ever arrive when other classes of public officials would be able thus to combine. We did not then anticipate that we should have to direct attention so soon to the necessity for combination on the part of Municipal Engineers and Surveyors. The action, however, of the Corporation of Congleton, who require a Borough Surveyor, who is to have charge of the Highways, Sanitary, Sewerage, Markets and Fairs, the Water and the Housing Departments —in place of Mr. J. H. Walters, who has fortunately been able to find a much more lucrative position—at a combined salary of £325, is a case in point. It is a very inadequate and improper salary. The time-tried alarum of economy was utilized, as is invariably the case when the salary of an officer is under consideration, and £250 was even seriously proposed as an adequate salary. Instead of leading to economy, efforts to obtain cheap men results in heavy cost to the ratepaying community, for competent men can save their Authorities much greater sums per annum than the amount of their annual salary, whilst incompetent men, through their inexperience, lose heavy sums, which councillors, not being technical men, are not able to discern. Some day we hope the time will arrive when the profession of a Municipal Engineer and Surveyor will be a closed one like that of the medical profession, when none can be appointed to a vacancy except a member or associate member of the Institution of Municipal and County Engineers or the Institution of Civil Engineers.

Managerial Functions, Union Labor and Politics in England

Editorial in The Engineer, London, April 28, 1922.

The efforts to maintain peace in the engineering trades have come to nought. On Monday last negotiations broke down, on the following day lock-out notices were posted in all Federated shops and on Tuesday next several hundreds of thousand more men will be thrown out of employment. Yesterday the Parliamentary Labour Party, at the request of the National Joint Council and the Amalgamated Engineering Union, invited Parliament to appoint an Industrial Court to investigate the matter in dispute, and on Monday the Employers' Federations informed the unions that in the event of such a Court being instituted, they would feel themselves no longer bound "by the terms of any proposals which have been made by them or on their behalf since the commencement of negotiations." The employers are still ready to resume discussion on the basis of their memorandum of Saturday last, but in view of the sequence of events outlined above and of the rejection of the memorandum referred to, the breakdown of the negotiations must be regarded as complete. The position is almost precisely what it was when two months ago the Federated shops were closed to members of the Amalgamated Engineering Union; the employers are still insisting on the right to exercise "managerial functions" and the unions are still endeavouring to diminish those rights almost to the vanishing point.

There comes a time in all unsuccessful negotiations when further discussion is fruitless, and no alternative remains but a trial of strength for mastership. Recognizing fully the seriousness of our words, we feel constrained to say that in our own opinion that time has now arrived in the engineering industry. For years past negotiations and discussions have followed fast upon each other's heels, and have been succeeded by compromise upon compromise. But they have brought us no nearer industrial peace, and the question forces itself upon us whether it would not be better once for all to determine who is to be the master than to continue these unending repetitions of a struggle which always ends indecisively, and hence leaves always encouragement to those who desire to renew it. We have no desire at all to see trade unionism destroyed, but we are far from certain that it would not be well for the country as a whole that the trade unions as they now exist should be removed, and that their place should be taken by new societies inspired by a different spirit. The evidence is too strong to admit of any doubt that the unions as they now exist are in a large measure political bodies, and that they exercise the peculiar powers which misguided Parliaments have conferred upon them to further their own political ends. It is so plainly undesirable that the industries of the country should be made the shuttlecock of political partisans that the necessity of reducing as far as humanly possible that element in trade unionism must be manifest to all save those who desire to use it for their own purposes. But whilst the political factor in modern trades unionism is one of those things that it is desirable to remove, it is, perhaps, neither the greatest nor the most sinister. It will always be countered to a material degree by the political differences of opinion which exist between man and man, even in the shop, and whilst it may from time to time lead to serious outbreaks, it is doubtful if in the end it can do so much harm to industry as the restrictions imposed or inspired by trades unionism on the development of factory efficiency. It is usual to estimate the damage effected by strikes as so many millions of working hours lost. There are fifteen million "workers" in this country. They do in all about three thousand million hours of work per month. If half a million go out on strike, they lose in all about one hundred million working hours per month, or, in round numbers, taken over the whole working population, about six and a half hours per month per person. The reduction of the working day from nine hours to eight means roughly the loss of twenty-four hours a month and the effect of the various systems of restricting output, if we put it as low as twelve per cent., means the loss of as much again. It must, moreover, be remembered that the loss owing to short hours and restricted output is continuous, so that the total number of hours lost per year from those two causes amounts to over five hundred and seventy per person, as against the six and a half lost in a one-month's strike. We do not present these figures with any intention of depreciating the harm done by a strike or lock-out, which extends, as a matter of fact, far beyond the mere loss of hours, but to make clear, in the terms of a factor that is commonly used, the waste of the industrial power of the country which was brought about by the wholesale shortening of working hours combined with resistance to the adoption of means for accelerating output and the extension of the "ca' canny" principle. The comparison we have made shows that had as a strike or a lock-out may be, it is far less injurious, measured in hours lost, than shortening the working day and reducing output per man. It shows also that the employers on economic grounds are justified in locking out if thereby they can secure conditions which will enable them to increase, though it be but in a small measure, the productive efficiency of their factories.

It is always said by the advocates of peace at any price that a fight to the end must leave soreness of spirit behind it, and engender hatred and revenge. That statement may be accepted as a truth; but we would point out in the first place, that class hatred is already encouraged by the men who are foremost in fomenting these troubles, and that we shall be no worse off for having them as avowed enemies, and, in the second place, we assert that in the unions there are large numbers of men who would only be too glad to see the turbulent element overthrown—men who would like to be left to live their lives peacefully and industriously; men who are glad to leave to the employers the responsibilities that are rightly theirs; men who would gladly work to their highest efficiency, and who would take pride in their work and in their firms. We invite the unions in the present dispute to put the matter to the test. Let them, rather than invoking the doubtful aid of an Industrial Court, ask Parliament to arrange for a secret ballot of all workers engaged in the engineering and allied trades on this single issue of managerial functions. The issue at stake in this dispute is far greater than appears on the surface. It cannot be settled, as some seem to imagine, by the discovery of a formula. It it no less than the right of the employer to increase the labour efficiency of his factory. For that he must contend if the engineering industries of Great Britain are to hold their position against world competition.

Concrete Railway Cars

From Zement, Berlin.

The first 15-ton railway car built for the Minden Concrete Works has been submitted to the German Official Railway Testing Station for examination. It has proved remarkably resistant to shocks and blows, even to collisions, yet its weight is only 1 ton more than that of a steel car of the same capacity, whilst its cost is much less. For larger sizes, the advantages are all in favor of the concrete car. These include low maintenance and repair costs, and great resistance to corrosion. The latter has been the cause of a Lubeck firm employing concrete cars for blast furnace slag, as the sulphur in this material rapidly corrodes steel and iron cars. Another use of concrete is for repairing old cars by building a concrete body on the old framework; cars so repaired have been quite satisfactory.

The Life of Switches and Crossings

Editorial in The Railway Engineer, London.

It is a well-known fact that the life of railway switches and crossings—or, to be more precise, of the rails of which they are mainly composed—is, on the average, considerably shorter than that of "plain road," in all cases where steel rails of the same quality are employed both for switches and crossings and also for ordinary track work. The explanation of this disparity in wear is found in the exceptional stresses to which switch and crossing work is subjected during the passage of trains over it; crossings in particular suffer a succession of blows as the wheels pass over the gaps formed by the flange ways. Thus complex problems in regard to both rigidity and flexibility present themselves in regard to the construction of the crossing itself, if it is successfully to resist these disruptive forces, while another problem altogether arises out of the rapid wearing away of the planed point-rail of the crossing, and the two wing rails at the knuckle, under the pounding that they receive from the wheels. It is with this question of rapid abrasive wear that we are concerned at the moment.

Various methods have been adopted by different railway companies with a view to overcoming this difficulty. Of these one of the most successful and widely-used has been that of hardening the crossing points and the knuckles of the wing rails by means of heating them to a suitable temperature, and then quenching them in cold water. The results of this quench-hardening first become evident when the carbon content in steel has reached 0.25 per cent, and are maximum when the content of carbon has risen to from 0.7 to 1 per cent. The head of the rail is heated to a point above the critical temperature of the steel, a higher temperature being necessary in a low-carbon than in a high-carbon steel to produce the maximum hardening effect, and the result of the sudden cooling in water is to produce a "layer" or casing of steel around the head of the rail in an intensely hard condition. Certain treatments include the "potashing" of the head—that is, well rubbing the top surface of the head with ferro-prussiate of potash when the former is at a blood-red heat—whereby the carbon content of a very thin lamina of steel round the head is increased, in a 0.5 per cent carbon rail, to something like 1 per cent, and full case-hardening of the head has been tried, although the latter is by comparison an expensive treatment.

The general effect of each variety of the treatment is the same—a fully martensitic structure, "glass-hard," is produced to a depth of about one-sixteenth of an inch under the outer skin of the head of the rail; from there to a depth of one-quarter to three-eighths of an inch the structure is partly martensitic and partly troostitic; while the interior of the head, together with the lower part of the web and the foot (assuming that the head only has been heated and quenched) are but little affected. The intensely hard outer casing of the rail protects it for an indefinite period against the effects of abrasive wear, and the result of this simple treatment is to lengthen the life of the rails concerned, on the average, some three or four times, as compared with untreated rails of the same chemical composition and properties. One leading British railway company has made a practice of hardening crossing rails in this way from 35 to 45 years continuously, and several others also carry it out regularly, with a material reduction of maintenance costs to set against a very small figure for the treatment itself. We are not aware of the same hardening treatment having been applied to switch rails.

It is an important fact to notice that railways carrying out regular quench-hardening treatment for rails have in most cases been working hitherto to a rail specification which does not permit of a higher carbon content in the steel than 0.5 per cent. Now that rail steel is becoming considerably harder steels, up to 0.65 per cent carbon and even higher being freely accepted by many lines, the question arises as to whether quench-hardening can any longer be carried out without risk, where high carbon steels of this character are in use, owing to the brittleness inevitably produced in the hardened portion of the rail. That considerable strains are set up in the internal structure of the rail during the process of hardening is evident from the fact that the hardened rail is seldom entirely free from twist after the conclusion of the operation. Minute quench-flaws, generally present in at least some degree after hardening, sometimes take the more serious form of a crack extending horizontally along the rail-web, showing that the steel has been unable to withstand the strain set up during cooling at the junction between the hardened and unhardened portions. The last-mentioned danger is further increased by the fact that it is practically impossible to detect, short of polishing and taking a sulphur print off the end of each rail prior to treatment, whether or no there be any segregation of carbon present in the rail, as a result of insufficient cropping of the rail ingot at the rolling mill or for other reasons. Such segregation, which is not easily revealed by ordinary external scrutiny, might mean that a rail from a cast containing, say, 0.65 per cent of carbon, actually contained a segregated area with a carbon percentage up to 0.9 per cent, and would render quench-hardening an extremely risky proceeding.

To set against increased life at small cost, there is therefore the factor of uncertainty of result, which is not negligible where safety of running is directly concerned. Strictly speaking, if any degree of certainty is to be obtained, every rail hardened should be treated on its own merits—a procedure which would be so costly as to nullify the saving. In brief, whereas the rail steel of yesterday, because of its low carbon quality, possessed a "latitude" in its properties which made available the full benefit of hardening treatment with little or none of its risk, the high carbon rail steel of today is on a different footing altogether. The composition of the latter represents the safe limits to which carbon and other hardening elements in the steel may be permitted; the rails so made are the product of a definite and carefully thought-out heat treatment during the course of rolling; and the tests are the purchaser's safeguard against brittleness in the finished product of these chemical and physical processes. If the falling weight test on the finished rail represents the purchaser's minimum standard of safety, then, logically, the hardened rail should withstand the test—a thing which, if the rail has been properly hardened, is unlikely to happen.

What effective alternatives to quench-hardening present themselves? In the first place, the high carbon steel rail itself is of considerably greater wearing capacity than the lower carbon rail that was previously the subject of hardening treatment, and if the actual cost of hardening be taken into account, the advantage of the hardened low carbon over the untreated high carbon rail is very materially reduced, while at the same time the risk attaching to hardening is done away with. A better plan, perhaps, than this, is to employ steels of special composition in order to increase the life of switch and crossing rails, or steels in the manufacture of which special heat treatments—such as the Sorbitic treatment associated with the name of Messrs. C. P. Sandberg—form a recognized part. Among steel alloys, nickel-chrome steel, of a cost somewhat higher than ordinary steel but a hard-wearing quality more than proportionately higher still, has now passed beyond the experimental stage, so far as rails are concerned; and the astonishing resistance to abrasive wear of high manganese steel, which, at a cost some four times that of ordinary steel, is coming increasingly into use on all hands in switch and crossing locations where very heavy traffic is carried, is too well-known to need recapitulation.

Activated Sludge Treatment in America

Editorial in The Surveyor, London.

English engineers do well to note the many experiments which are continually being made in America. These experiments throw much light on our own work, they are well reported, and even the failures are described fully. Our own failures generally are not reported in the public Press at all; hence error has less chance of being checked. It appears from an article in Engineering News-Record that experiments have been made at the City of Pasadena, in California, in which aëration and agitation were effected by pumping sewage and air into the bottom of the activation tank through revolving perforated arms. Centrifugal pumps were used, drawing both sewage and air. The point which engineers should appreciate is that the aëration proved to be insufficient, that supplementary air blowers and diffusers were found to be necessary, and that the system took twice the time to operate and was more costly than the recognized activated sludge process of agitation by diffused air without moving machinery. This method should be compared with a similar method employed at Hermosa Beach, California, in which a diffusion wheel or impeller type of pump at the foot of the intake pipe was used for drawing in both air and sewage. In this case we are told again that the aëration produced was insufficient. To those aware of the possibilities of air locks, a glance at the design of the Pasadena plant at once suggests the air locks must occur. The lesson appears to be first that aëration cannot be effected economically by means of plain nozzles, and next that mechanical agitation is no substitute for aëration and will not alone purify sewage. There seems to be a prevalent idea that agitation alone possesses some peculiar merit, but there are no grounds for the belief.

The Architect and Advertising

By SIR CHARLES T. RUTHEN.

President of the Society of Architects.

From The Surveyor, London.

During the past few years I have been driven to the consideration of the subject of the position occupied by architects and architecture in the social system of today. The general public have little knowledge of the real value of the architect and his craft to modern progress and civilization. Some, but comparatively few, understand the architect and value his work. Many others look upon the architect as a kind of necessary and expensive evil, mainly useful in connection with building matters, in avoiding difficulties in relation to regulations and by-laws; but generally a costly luxury to be avoided whenever possible. Still many more possess the haziest idea about the architect and his work, and are disposed to consider, in any event, that he may be useful to the few but is much better done without by the masses.

In turning these vital matters over and over in one's mind, the fact is very surely borne in upon one that the great public who, unconsciously and in a matter-of-fact way, avail themselves every hour of the day and every hour of the night, of the product, good, bad, or indifferent, of the great craft of building, have not the faintest idea of the important part played by the members of the architectural profession in the everyday life of the people.

One wonders whether the architect attaches to himself any share of the blame for this fatal and disastrous ignorance upon the part of the people, or whether he sometimes stops to think, and perchance realizes that this lack of understanding is after all due, if not entirely, in a large measure, to the strange backwardness, perhaps one would be more correct to say selfishness, upon the part of the entire profession. A backwardness or selfishness which is having a very baneful effect upon the fortunes of this great and honorable craft.

Better that the architect adopted the practice—often termed pernicious, but very consistently condemned in our country—extensively and even successively practiced on the other side of the Atlantic—of advertising his wares and his services in the manner popular with any great drapery store or furniture emporium. Architects must not advertise, they must not offer their services; this would be a gross breach of professional etiquette; they must remain silent and trust to some piece of good fortune; to the winning of some competition; to the favor of some important or wealthy client to bring them publicity or perchance fame.

That the advertising of one's wares like some vendor of ordinary or extraordinary soap, or hair restorer, is repugnant and offensive to the sensitive feelings of the architect, brooks no argument; but to lie low and bide the gifts of the Creator under a bushel and to refuse or neglect to let the public learn of the value to modern life of good architecture is a crime. It is wrong to architecture as an art, wrong to architecture as a science, and wrong to the public whom the architect should serve.

The present stand of architects is perhaps agreeable to the few; shall I say even satisfactory to the few? At the top of the professional ladder there is much room, but the lower the rungs the greater the crowd, and the more congested and cramped the accommodation. To the many the present practice is mere false pride, backed by generations of narrow outlook, and love for the profession which forgets its service to the people.

An architectural debating society—one has never heard of such a society, but perhaps the idea is worth cultivating—looking for a fit subject for debate, might adopt one of the following rather amusing titles, which would, I feel sure, provide much food for consideration and débate:

(a) "What is advertising as applied to architects and their work?"

(b) "Is advertising that for which payment is made in cash at ordinary advertisement rates?"

(c) "Is advertising not advertising if no payment is made for insertion, and when the matter appears in that part of the journal usually read by the greatest number of readers?"

One may object "to advertise" oneself or one's own work, in the sense of paying so much per line in the advertisement columns of a newspaper or periodical; but one may not object "to being advertised," or to being written about or of, in the ordinary news columns of a newspaper or periodical. This is cheaper, and incidentally more efficacious, but it is nevertheless advertising. It will be generally agreed by those who observe even casually that those highest up the ladder of fame get the most publicity—sometimes called advertisement, and rightly so—and that free, and the lowest upon the ladder, the least publicity, and very possibly have to pay directly or indirectly for that which they get.

The Evolution of the Municipal Engineer

By H. PERCY BOULNOIS,

From The Engineer, London.

In reading in the last issue of The Surveyor the papers and discussions at the Cardiff meeting, I was greatly struck with the knowledge and professional acumen of the municipal engineers and surveyors of the present day compared with the past.

This was brought home to me as I had quite recently been reading the "Special Report of the Health of Towns Commission," published in 1845, in which there is a report by Mr. Lee, the then surveyor of highways of Sheffield, in which he says, inter alia, speaking of the evils which then existed, that his predecessor in office "'who was employed for many years, could neither read nor write." It must be remembered that in these days the "surveyor of highways" had to perform the general duties of a surveyor, and Mr. Lee further says of his predecessor that "he recommended and overlooked the making of common [public] sewers without level, plan, specifications, and, of course, without any regard to the dimensions required in the locality. Within the last eight years several miles of such sewers have required to be entirely reconstructed." This was about 80 years ago, but in 1875 the late Dr. Acland, speaking of the surveyor, said: "We all remember the plodding, energetic man of highways and byways whose Anglo-Saxon vigor broke forth from the garb of corduroy to the surveyor of the present day who may be called upon to advise on anything from the form and cost of an earthenware syphon trap to the calculation for work to be done by engines which are to supply half a million persons with water, and be responsible for the construction of sanitary mechanisms from a housemaid's sink to an intermittent filtration farm."

What would Dr. Acland have said now had he been alive and could have seen the enormous strides that had been made by surveyors since that date?

I have been closely connected with municipal engineering for more than 50 years, and can speak from personal observation of the almost phenomenal growth of the profession, and the advancement in the education and training of the municipal surveyor.

This evolution has been the more extraordinary when we consider the amount of opposition he has so often encountered owing to the prejudice and ignorance of the general public. Sanitation has never been a popular subject. The expenditure of money on seemingly unproductive works has never appealed to the ratepayer, who prefers to see some definite return for his money; but some day a better understanding will develop and the well-equipped scientific surveyor of today will be given his proper position as an adviser of the nation.

Recent Developments in British Excavating Machines

By F. H. LIVENS and W. BARNES of Lincoln.

From Engineering, London, Abstract of a paper read before the Institution of Mechanical Engineers.

Much progress has been made with the steam excavator, commonly known as the steam navvy. Up to a comparatively recent date, contractors had practically a monopoly in the use of these machines for public works such as railways, canals, and docks, but now more excavators are used in open mines and quarries, in more or less permanent situations, than for contract work. The change is due partly to the difficulties of the quarry owner as regards labor and the necessity for keeping costs down under present-day competition, but also to the introduction of machines more applicable to his special working conditions.

The original steam navvy, which was capable of swinging or slewing its excavating gear through a little more than half a circle, has been now displaced to a large extent by the full circle machine, commonly known as the steam-crane navvy, and developments of this latter type are what the quarry owner and general user find so useful for their work.

The size of machine most suitable for various workings is governed chiefly by:

(a) The nature of the material, and

(b) The output required per day.

The former will determine the minimum cutting effort to be used. For example:

4 tons to 6 tons is suitable for material up to clay of medium hardness.

8 tons to 10 tons is suitable for stiff clay.

12 tons to 20 tons is suitable for boulder clay.

20 tons to 30 tons is suitable for heavier material. such as limestone and heavy iron ore.

The output depends also upon the size of the bucket, which again is governed by the nature of the material to be excavated; thus a machine having 6 tons cutting effort is most efficient when fitted with a bucket of ¾ to 1 cu. yd. capacity; if 12 tons, then the bucket should hold from 1½ to 2 cu. yd.; and if 20 tons, from 2½ to 3½ cu. yd., to give approximate examples.

Type of Steam Shovel Most Generally Used.—The machine shown in Fig. 1 is the type and size of machines in most general use, and is also interesting from the modifications which can be made in it to meet various conditions of working. Its weight is 55 tons net or 62 tons in working order. With the length of jib shown, the machine has sufficient stability for 20 tons cutting effort on the bucket teeth, or, if used as a crane, it will lift a load of 20 tons.

The machine is capable of dealing with from—

120 cu. yd. to 150 cu. yd. of ordinary soil or light clay per hour.

100 cu. yd. to 1,200 cu. yd. of stiff clay per hour.

60 cu. yd. to 100 cu. yd. of ironstone per hour.

60 cu. yd. to 80 cu. yd. of loose limestone per hour.

The following is a fair average of the working costs per cubic yards loaded into wagons:

	Per hour. s.	 d.
One driver	2	0
One cranesman	1	3
One fireman	1	0
Four men around the machine	5	0
3 cwts. to 4 cwts. of coal	5	6
Oil and stores	0	9
Total	15	6

s = 24 ct.; d = 2 ct.

This represents a cost of approximately 1½d. per cubic yard for the maximum output of easy material and 3d. for the heavy material.

Combined Steam Shovel and Grab Bucket.—Another interesting modification is the combined steam navvy and grab It is a dual purpose machine, and was designed and built to work in an ironstone quarry from which the amount of ironstone required was only sufficient to keep a steam navvy employed rather less than half its time. Overlaying the ironstone was about 8 ft. of material which had to be taken off before the ironstone could be excavated, and the proposition was that the same machine might be used both to remove the cover or overburden and to dig the ironstone.

The jib of the steam navvy was therefore extended and fitted with a grab to enable it not only to have enough reach to lay bare a sufficient quantity of ironstone, but to discharge the overburden on to the ground from which the ironstone had been removed.

Two hoisting drums are fitted to the main drum shaft, one for use with the steam navvy bucket, and the other for use with the grab. The same hoisting clutch and brake are common to both drums. and they are so arranged that either of the drums can be connected or disconnected at will. When the grab is required to remove the cover, the bucket is fastened back to the underside of the jib and the grabbing drum is connected to the hoisting clutch and brake. After sufficient cover has been removed, as much, in fact, as the machine can reach, the grab is disconnected and the steam navvy drum is engaged. The machine then works as a standard steam navvy and can dig the stone which the grab has uncovered.

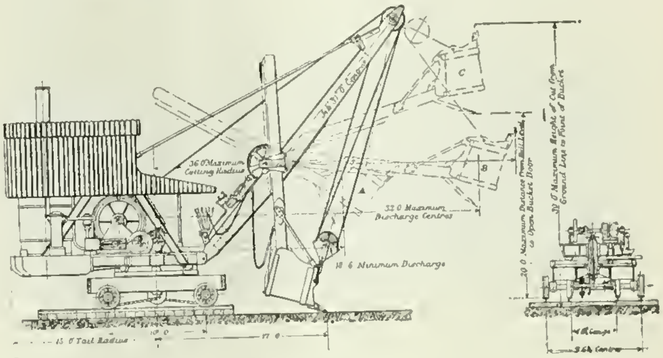
36 0 Maximum Cutting Radius
33 0 Maximum Discharge Centres
18 6 Minimum Discharge
20 0 Maximum Distance from Rail Level to Open Bucket Door
30 0 Maximum Height of Cut from Ground Line to Point of Bucket
A
B
C
15 0 Tail Radius
10 0
17 0
Gauge
Centres

Fig. 1—Typical General Purpose Steam Shovel.

Steam Shovel with Extra Long Bucket Arm.—Another useful modification is the machine shown in Fig. 2, which has an extended jib and bucket arm to enable the excavated material to be discharged 60 ft. from the center of the machine as compared with the 32 ft. of the standard machine shown in Fig. 1. This was specially designed for open-worked quarries in which the overburden had to be dumped from the bucket, back on to the ground from which the mineral had been removed. The machine stands upon the mineral, which in the illustration is ironstone, and will excavate ordinary soil or clay at the rate of 25 cu. yd. to 50 cu. yd. per hour. It is obvious that when the jib is lengthened to the extent described, the cutting effort upon the teeth must be considerably less than in the standard navvy, otherwise the machine will not be stable. The bucket must also be diminished correspondingly in size. Consequently the cutting power is reduced in this instance to 7 tons and the bucket has a capacity of 1¼ cu. yd.

The discharging radius also governs the depth of cover the machine can deal with. This particular machine, with its 60 ft. discharging centers, will deal with from 15 ft. to 20 ft. of cover. If it were required to remove a greater depth than this, a machine with a still longer reach must be used, and if heavier cover than that indicated has to be dealt with, or in larger quantities, a more powerful machine with a larger bucket must be employed. Very large machines of this type are now in operation, weighing upwards of 300 tons in working order, and carrying buckets of 7 cu. yd. capacity,

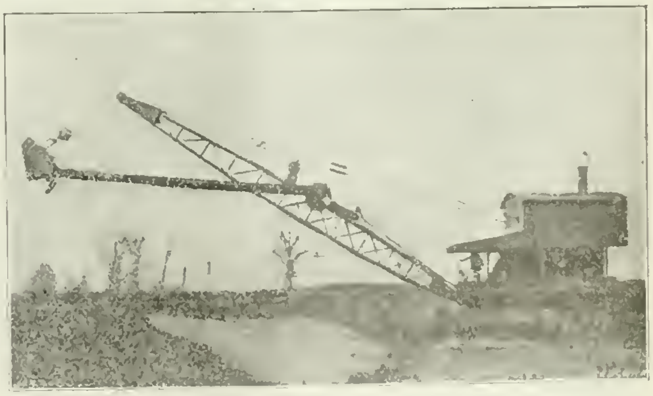

Fig. 2—Crane Navvy with Extra Long Bucket Arm and Jib.

capable of dealing with 200 cu. yd. to 300 cu. yd. of material per hour. Such machines have a discharging radius of 100 ft. They are naturally slower in working than lighter machines, the time taken to make a complete cycle of operations being from 50 secs. to 65 secs.

Steam Shovel Working in Conjunction with Transporter.—As alternative to the long jib-crane navvy for removing and dumping quarry overburden direct, is an excavator with a normal length of jib, working in conjunction with a transporter, for taking away the excavated material and dumping it, as shown in Fig. 3. The navvy itself is exactly similar to the one described in connection with Fig. 1, and stands upon mineral.

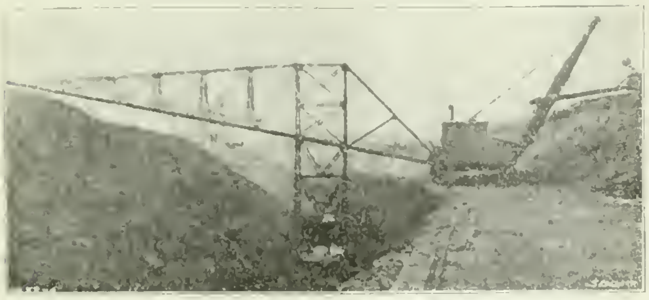

Fig. 3—Crane Navvy Working in Conjunction with a Transporter.

The transporter travels in the bottom of the quarry and consists of an underframe and tower, supporting a double cantilever track for the wagon or skip. This underframe is fitted with the necessary wheels and traveling gear which enable it to be moved about the quarry under its own power, and on the underframe are the boiler and winding engines for actuating the transporting gear, which are sufficiently large to haul a fully loaded skip up the inclined track at a speed to suit the excavator, and, in addition, supplying the power for traveling. The skip is about 25 per cent larger than the excavator bucket to avoid spillage. It is fitted with a hinged door similar in principle to the bucket of the digger, but arranged so that it can be opened at any desired point along the transporter track by means of a movable tripping jack, which is traversed by a small hand winch on the transporter, within easy reach of the driver.

The transporter wagon makes a round trip in 25 seconds, which is several seconds quicker than the average cycle of operations on the excavator, so as to avoid the latter having to wait for the transporter. It really follows the axiom of the ideal contractor, who should arrange his wagon service so that his steam navvy never waits for empties. An output of 80 cu. yd. to 120 cu. yd. of ordinary material can be obtained per hour.

Combined Excavator and Transporter.—The machine, (Fig. 4) is a single-bucket excavator carrying a wagon transporter supported by a common tower and main frame, and weighs about 85 tons. The method of discharging the material into the wagon is its most novel feature, as, instead of the bucket being swung round over the wagon in the usual way, the hoisting is continued after the cut is finished, until the bucket is pulled right into the jib and immediately over the top of a chute fitted between the sides of the jib.

Just as the bucket is coming over the mouth of the chute, the catch holding the door in place is mechanically pulled off, the door falls and the contents of the bucket are discharged down the chute into the wagon standing on the transporter track at the foot of the chute. The excavating gear only swings through a little more than half a circle, and the bottom center of the chute coincides with the slewing center of the machine, so that the wagon, when lowered down as far as it will go, is also immediately over the slewing center, and is, therefore, always correctly placed, irrespective of the position of the jib. The underframe of the machine is triangular in plan and is fitted with three bogies, one at the front immediately under the slewing center, the other two at each end of the underframe at the dumping side. The platform of the underframe supports the tower and carries the boiler, transporter engines, and a separate set of self-contained engines for slewing. The main hoisting or digging engines are mounted upon an upper story of the tower and above the track of the transporter. The bucket has a capacity of 2 cu. yd. Two men are sufficient to operate the various motions, one the driver of the transporter engines, who also attends to the firing of the boiler, and another who controls the excavating mechanism. The machine can complete a cycle of operations in 20 seconds, and is capable of an output of 60 cu. yd. to 80 cu. yd. of heavy clay per hour.

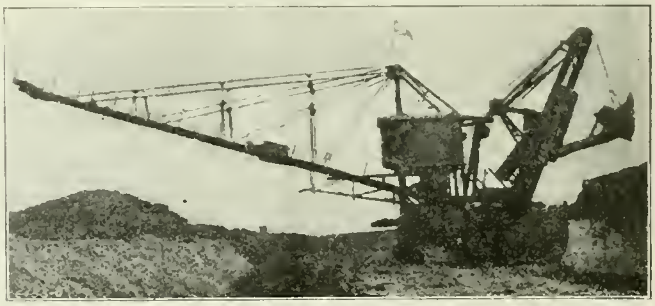

Fig. 4—Combined Excavator and Transporter Removing Cover from Ironstone.

Endless Bucket Excavator Combined with Belt Conveyor.—When the material is light and easy to dig, the endless-bucket type of excavator, feeding on to a belt-conveyor may be a very useful and efficient combination, as shown in Fig. 5. This shows a machine which is the largest of its kind and is operated electrically by three-phase current. It is

TABLE I.

Net weight and Type of Machine.	Material Excavated.	Capacity of Bucket.	Duration of Time Working.		Net Working Time.		Time Lost from:	Total Number of Cycles of Operation or Cuts.	Average Cuts per Hour, Inclusive of Time Lost.	Average Cuts per Hour Exclusive of Time Lost.	Total Amount of Material Excavated.	Average Quantity per Cut.	Average Output per Hour, Inclusive of Lost Time. A	Average Output per Hour, Exclusive of Lost Time. B
		cu.yd.	hr.	min.	hr.	min.								
55 tons crane navvy.	Ironstone, fairly easy to dig.	2.75	2	2	1	18	Waiting for wagons, 33 min. Moving up, 11 min	109	54	84	254 tons	2.34 tons	125 tons	196 tons
55 tons crane navvy.	Heavy ironstone.	2.75	1	57	1	22	Waiting for wagons, 29 min. Moving up, 6 min	99	51	72	228 tons	2.30 tons	117 tons	167 tons
56 tons long jib crane navvy, 60 ft. discharging center.	Sand	1.50	1	29	1	7	Moving up, 22 min.	110	74	99	120 cu. yd.	1.1 cu. yd.	81 cu. yd.	107 cu. yd.
55 tons crane navvy working with transporter.	Stiff clay and loam.	2.75	2	26	1	47	Moving up, 39 min	191	79	107	380 cu. yd.	2 cu. yd.	156 cu. yd.	213 cu. yd.
43 tons crane navvy working with transporter.	Stiff clay and loam.	2	1	25	1	17	Moving up, 5 min. Waiting for skip, 3 min.	126	89	98	226 cu. yd.	1.8 cu. yd.	160 cu. yd.	176 cu. yd.
85 tons combined excavator and transporter.	Stiff clay and sandstone.	2	1	36	1	16	Moving up, 20 min.	129	81	102	170 cu. yd.	1.32 cu. yd.	106 cu. yd.	134 cu. yd.
120 tons crane navvy.	Veary heavy Ironstone.	4	1	40		50	Waiting for wagons, 40 min. Changing wagons, 10 min.	71	43	85	269 tons	3.8 tons	161 tons	321 tons

NOTE.—These are ordinary working speeds and outputs. It will be seen that the actual outputs per hour in column A are from 50 per cent to 85 per cent of those in column B. Compared with these, an average man can excavate from 1 cu. yd. of clay or limestone to 2 cu. yd. of sand per hour.

capable of an output of 80 cu. yd. to 150 cu. yd. per hour, and was designed to remove 50 ft. of overburden consisting of sand, peat and gravel. The bucket ladder is approximately 100 ft. long, and the conveyor 130 ft. long.

Small Steam Shovels.—One result of the present-day labor situation is the demand for a small machine, due not only to the high wages which have to be paid, but to the increasing disinclination of men to work with pick and shovel. Previous to the war, hand labor was so cheap that for small outputs there was little margin to cover the charges incidental to the use of machinery; therefore, comparatively few excavators below 30 tons in weight and 8 tons cutting effort on the teeth were used in this country. Labor conditions have now so altered, however, that brick manufacturers, quarry owners and small contractors must have something more economical than hand work. In general design and working the machine is similar to the larger machine previously described, but it only weighs about 16 tons net, and carries a bucket of ⅝ cu. yd. capacity, with 5 tons cutting effort upon the teeth.

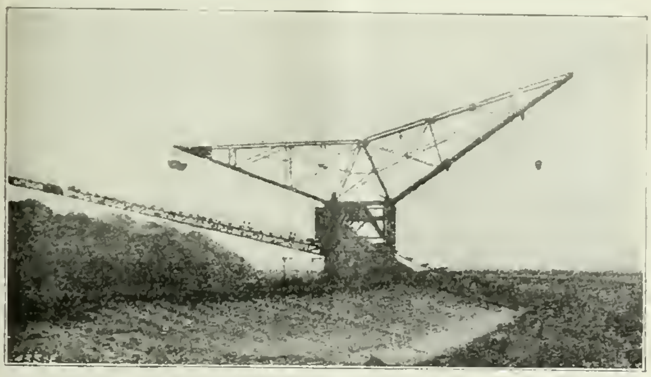

Fig. 5—Endless Bucket Excavator Combined with Belt Conveyor.

It will deal with any class of material up to fairly stiff clay, in quantities up to 50 cu. yd. per hour; in fact, in many places, such as brickworks, an output of 6 cu. yd. to 7 cu. yd. per hour may be all that is required, and quite a number of machines are replacing hand labor even for this small output. For the maximum output, two men upon the machine and two or three around can be usefully employed, but for small outputs one man upon the machine and one or two around it are sufficient.

A modification of this small machine is used for loading coke from a levelcoke-oven bench. Instead of being fitted with the usual steam navvy bucket, it carries a large fork, 4 ft. 6 in. wide, arranged with tines similar to a hand fork. The racking motion for regulating the stroke of the bucket-arm is also differently arranged, as, instead of the point of suspension being fixed and the working length of the arm varied, as in the case of the steam navvies previously described, the length of working radius of the arm is fixed, and the suspension point is racked in or out horizontally. This enables the fork to be thrust along the bench underneath the coke so as to avoid breaking it.

British Road Expenditures

From The Surveyor, London.

The subjoined figures, prepared by the Ministry of Transport, give estimated expenditure on road improvement and maintenance by highway authorities in Great Britain during the year ended March 31 last; the estimated expenditure by the same authorities for the same purposes during the current year; the estimated proportion of that expenditure in respect of which grants from the Road Fund have been or will be made; and the total estimated grants from the Road Fund in respect of Class I and Class II roads, respectively, for each of the two years:

Estimated expenditures by highway authorities during—	
1921-22	£45,000,000
1922-23	40,000,000
Grants from road funds durin—	
1921-22	26 per cent
1922-23 (estimated)	28 per cent
Road fund grants to Class I and II.—Roads and bridges—	
During 1921-22, Class I, £6,347,000; Class II, £1,027,000	£7,374,000
During 1922-23, Class I, £6,600,000; Class II, £1,900,000	8,500,000

As these figures are to some extent estimates, they must be regarded as approximate only.

Construction Features of Harbor Works at Valparaiso

From The Times Engineering Supplement, London.

An account of the works carried out for the improvement of the port of Valparaiso by Messrs. S. Pearson & Son under a contract made in 1912 with the Chilean government for the sum of £2,500,000 was given before the Institution of Civil Engineers by Mr. A. C. Walsh and Mr. W. F. Stanton, the former of whom was the contractors' representative at Valparaiso and the latter the chief engineer.

The works included (1) the breakwater (first section 165 meters, second section 123 meters); (2) custom house quay (630 meters); (3) reconstruction and extension (370 meters) of the old fiscal mole constructed in 1883; (4) Prat quay (210 meters); (5) mooring jetty (250 by 100 meters); (6) coal wharf (200 by 50 meters); (7) sea wall between mooring jetty and rubble slope (745 meters); (8) rubble slopes (1,660 meters); (9) warehouses, sheds, railways and paving; and (10) sundry work for the permanent equipment. The time originally set for the completion of the contract was seven years. There were various causes of delay, the war not being the least, but nevertheless Nos. 1, 2, 4, 6 and 8 are now complete, and Nos. 3, 5 and 7 are well advanced.

Protection Against the Teredo.—For providing the stone required, quarries were opened at Las Salinas on the eastern side of Valparaiso Bay, about 7½ km. by water from the breakwater, and on a level strip of beach some 200 meters wide, and block-making yard, crushing plant, workshop, foundry and stores were established. A temporary jetty 700 ft. long was constructed for shipping rubble and blocks and for receiving coal, stores and current. It was built partly of timber piles but mostly of reinforced concrete piles. The first method tried for protecting the timber from the teredo was to drive in a number of nails and round them fix a light shutter to be filled with cement grout. This expedient had been used successfully by the authors at Vera Cruz and at Malta, but at Las Salinas the ordinary shutter did not prove strong enough to resist the heavy seas. A trial was then made of covering a pile in the dry before pitching, and a piece of wire netting was added as reinforcement. The mortar was allowed two weeks in which to set before driving, but owing to the vibrations caused by driving the mortar skin cracked and spalled. Finally the piles, after being painted with tar, were covered with a layer of felt and Muntz-metal sheeting. The force of the breakers, aided by pieces of floating wreckage, however, destroyed this covering and left the timber exposed.

Two years after it had been driven one of the piles was found to be completely eaten through at water level, and examination showed that many of the others, especially those that had been driven before the adoption of the Muntz-metal sheeting, were in little better condition. As serious interference with traffic would have been caused by renewing these piles, the bracings and clips were removed from one pile at a time, and iron cylinders, divided in half longitudinally, were bolted together round the pile. These cylinders, which had a clearance of about 1 in. at the corners of the pile, were assembled above water level, lowered to the bottom, and driven down about 3 ft. into the sand by screw-jacks; they were then filled with fine crushed stone and grouted by means of a pipe introduced for the purpose, after which the bracings were replaced. This method proved entirely successful, and the extra weight of cylinders and concrete greatly improved the steadiness of the structure in a heavy sea.

The bracing of the jetty consisted of horizontal struts of old bull-headed rail, with diagonal tension rods 2 in. in diameter, the connection with the piles being effected by ¾ in. bent plates clipped to the pile by 1¾ in. diameter bolts, which also passed through the ends of the bracings. These bolts, and the union boxes of the tie-rods, when they occurred below water, became a source of anxiety after a few years. The threads in some cases were affected by the solvent action of the water, while the continuous vibration due to the heavy seas ground away the weakened threads until the nuts dropped off and the bolts fell out or the tie-rod came in half. The solvent action of the water was particularly marked in the neighborhood of the timber piles sheeted with Muntz metal. Two timber piles near the outer end of the jetty were not enclosed in concrete, and as they were not exposed to breakers the Muntz-metal covering on them did not suffer. Galvanic action, however, was set up between the Muntz metal and the iron of the bracing clips, and, in consequence, the latter had to be removed four years after they had been placed, their edges, which were originally $\frac{3}{4}$ in. thick, having been eaten down to a knife edge.

Breakwater.—The principal difficulties in providing protection to the bay were the great depth of water and the doubtful nature of the sea level. The first 165 meters of the breakwater from the shore extends out to a depth of 59 ft. below mean sea level and has a good sandy foundation. For this first section it was decided that a blockwork structure would suffice. On a rubble bank extending up to 16 ft. below mean sea level was built a solid blockwork superstructure, $13\frac{1}{2}$ meters wide, rising one meter above sea level, and this, after settling for a year, was carried up to 13 ft. with a mass concrete cap, on the sea side of which was placed a parapet 16 ft. wide extending up to 33 ft. At a depth of 39 ft. on the sea side the rubble bank forms a berm, on which rest 60-ton pell-mell blocks up to a level of $11\frac{1}{2}$ ft. above the sea.

At the outer end of the second section of the breakwater, 123 meters long, the depth of water is 147 ft., and under this section the compressibility of the bottom was found to increase until penetrations of 22 ft. were recorded with a pressure of $2\frac{3}{4}$ tons per square foot. A different type of superstructure was therefore regarded as necessary, and the section was built of six large monolithic blocks, each 20 meters long by 16 meters wide by 15 meters high, which were founded on a rubble bank deposited up to the level 46 ft. below the mean sea level. Each block weighs over 12,000 tons, and the whole is covered with a mass concrete cap up to a level of 13 ft., with a parapet rising to 25 ft. A triple row of 60-ton apron blocks protects the rubble bank along the sea side of the monoliths.

Each of the reinforced concrete shells of these monoliths weighed 2,400 tons and contained 140 tons of steel rods. As there was no suitable site where they could be built on shore and lanuched on inclined ways, they were built, three side by side, in a temporary dock formed by a coffer dam in a sheltered site behind the old Fiscal Mole

Placing the First Monolith.—As these monoliths in the second section of the breakwater are founded 9 meters lower than the blockwork of the first section, it was necessary to get the first of them into its permanent position before the blockwork could be finished, and therefore there was nothing against which to hold it and guide it into place. After being floated into approximate position the two inside corners were moored to the scar end by two $\frac{7}{8}$-in. wire cables, the length of which was then adjusted by hand winches on shore working through sets of blocks and falls to which the ends of the cables were attached. The function of these cables was to fix the distance of the monolith from the finished work. For maneuvering purposes the floating crane pontoon was lashed to one side of the monolith and a hopper barge to the other. Each of these craft had anchors out at angles of 45° with the center line of the breakwater, the anchor chains being controlled by steam winches on board the vessels. Two tugs also assisted in keeping the monolith in its correct position. The weight of the monolith at this stage was 4,000 tons, and its behavior while afloat had shown that it would be impossible so to moor it as to prevent all movement. Accordingly sinking operations were started on a calm morning a few hours before high water, so that when the monolith grounded out of position it was eased off again by the rising of the tide. The actual sinking was done by means of four 5-in. gate valves; and once the monolith was dragged into correct position it was pinned down with a 60-ton block deposited by the floating crane, an additional 300 tons of water ballast being then admitted to prevent risk of further movement.

The final position was found to be only 3 in. out of line and about 18 in. seaward of the intended position. As soon as the monolith was set in place a 5-ton crane was placed on top of it by the floating crane, and communication with the first section of the breakwater was obtained by a light trussed timber bridge 100 ft. long. Before the next high tide a considerable quantity of additional concrete ballast had been transported over the bridge and lowered to the bottom of the monolith by the 5-ton crane. The second and fifth compartments, which had been kept dry, were the first filled, and as the concrete rose in them the water was pumped out of the others. Concreting was carried on continuously day and night, Sundays excepted, for 18 consecutive days, until the work was finished.

Compared with the placing of the first monolith the disposal of the others was a simple affair. To control its alinement, the floating monolith was fitted with two walings of Oregon pine, 16 in. square and 15 ft. long, one on each side and projecting 2 ft. so as to overlap the monolith last set. These walings were connected together through the monolith walls by two strings of tie-rods situated as near the end walt as possible. In each string of tie-rods were included two heavy spiral mooring springs and a union screw. As each spring was capable of closing up 6 in. under a load of 15 tons, the combination was capable of allowing a movement of 12 in. to either waling with a resistance rising from 0 to 30 tons. In practice, however, about one-third of this movement was taken up by tightening the union screws, so that apart from the resistance of the timber either waling could be moved through a distance of 8 in. under a mean resistance of 20 tons. As the monolith and ballast weighed 4,000 tons, a waling could bring it to rest when moving at the rate of 29 ft. a minute. The back ends of the walings were secured to the monolith by short bolts through the outer walls at an angle of 45°, so as to resist any end blow which might be received while the monolith was being put into place. The monolith was drawn into position between the walings by means of blocks and tackles worked by winches bolted down to the last monolith filled. These tackles led in both a parallel and a diagonal direction to the breakwater; thus the monolith was held up tightly to the preceding monolith during the sinking operations.

The widths of the joints between the monoliths as set was very small, but in settling the outer four monoliths closed together, leaving a gap of 18 in. between the second and third of them. This was closed by walling up the outside of the joint with fine concrete in sacks placed by a diver, and then filling the interior with a small self-discharging skip made for the purpose.

French Hydraulic Schemes

From The Engineer, London.

A congress held in Bordeaux last June dealt fully with the hydraulic schemes to be carried out in the south-eastern departments of France. While these schemes form only part of the program for the electrification of the country, they are, nevertheless, the most important, and include such undertakings as the electrification of the Midi Railways, the construction of the Midi Canal and the utilization of the hydraulic power of the Dordogne. So much has been said about the electrical side of the program that the value of the inland navigation improvements appears to be overlooked. It is proposed to create four main water arteries, which will permit of navigation by boats of at least 1,200 tons, and they all aim at diverting traffic from Central Europe to the French seaboard, and at the same time of allowing cheap carriage of raw material to the works and factories and of iron ore and certain classes of manufactured goods to the ports for shipment. When the Rhone has been "canalized" there will be direct communication between Switzerland and Marseilles, while the connecting up of the Rhone with the Rhine will extend navigation facilities to the whole of the vast waterway system of Germany. The canals through the industrial districts in the north of France are to be linked up to divert traffic to Dunkirk, and with the proposed deeping of the Moselle there will be water communication between the northern port and the Rhine. Another scheme that is making slow but sure headway is the extension of the canal from the Department of the Rhone to Nantes, so that the great manufacturing region of Lyons and neighborhood may send goods by water for shipment. Of still more importance is the construction of the Midi Canal, which is to connect the Mediteranean with the Atlantic, and although its commercial value was debated for many years before the war, it was finally sanctioned and the want of funds alone prevented the undertaking from being carried out. The Bordeaux Congress strongly insisted upon the necessity of Parliament voting credits for the construction of the Midi and lateral canals, and at the same time urged that the State should encourage experiment with simple methods of boat propulsion that will not damage the canals.

Methods of Making Marine Surveys

By E. LATHAM and P. HARRISON.

From Engineering, London.

Marine surveys are in most cases required as a preliminary to designing and constructing piers, quays, jetties, or wharves. This class of survey differs essentially from ordinary field work and from geodetic surveys of precise character covering large areas. As the major portion of the work has to be done afloat, methods which would otherwise commend themselves on the grounds of their mathematical accuracy have to be abandoned and others proved practicable by experience have to be introduced.

Geological considerations and the nature of the sea or river bed in regard to their suitability for carrying the foundations of structural works are excluded from this article, which is confined to the following subjects:

(a) Levelling.
(b) Soundings.
(c) Current observations.

The above subjects are dealt with below:

Levelling.—Levelling in connection with proposed marine works is necessary to establish the exact relation between the bottom levels obtained by soundings and the foreshore levels between high and low-water mark and to determine their collective relationship with Ordnance Datum.

Observations with a "Y" or dumpy level are of a much more precise character than any observations which can be obtained with sounding lines or rods, and it is therefore always desirable that the levelling work on any range should be carried out at the period of the lowest available spring tide, and that there should be a distinct "overlap" between the soundings and the shore observations taken on the same range. This appears a simple result to obtain, but in practice it is difficult to secure. Wind, weather, and barometrical conditions materially effect low-water level, especially in estuarial waters, and L. W. O. S. T. is an extremely vague datum (physically as apart from mathematical calculation).

In connecting up the work of levelling with the corresponding soundings the following points have to be considered. The most favorable period for taking soundings is the short time during which slack water occurs at the bottom of the tide, and, leaving out exceptional cases, this gives the observer who takes the soundings not much more than two hours per diem, to work in, and the fall and rise of tide is then only a matter of a few inches. This, of course, only applies to soundings taken with a lead and in several fathoms of water. Where a sounding rod can be used the tidal currents cause less interference, and the period available for observation is longer. As soundings are taken from floating craft drawing a definite amount of water, it is clear that the soundings cannot be advanced shorewards much beyond extreme low-water mark. To secure the definite overlap with the levelling referred to above, it therefore follows that soundings should be taken where possible at neap tides at or near the time of low water.

A station point for referring all levels to must be established in the immedate vicinity of the sounding area, and this station point must be referred to a bench mark of known accuracy. In many cases dealt with by the writers, this question of known accuracy has proved troublesome. Unless the bench marks established by the Ordnance Survey are of recent date, their accuracy, especially in marsh lands and in the vicinity of recent dredging operations, is very much open to question. A considerable revision of the Ordnance Survey is now in operation, but many of the minor lines of triangulation are not yet completed. In respect of recent levelling in the parish of Vange, Essex, it was only possible to establish a reliable datum by working from a new Ordnance bench mark and applying to the Department at Southampton for information as to the level of the same. It frequently is necessary to ignore the local marks and to tie up the whole survey to a reliable bench mark (preferably on high ground) free from the liability of being affected by surface land movement. The term "surface land movement" is deliberately employed, as this is by no means confined to subsidence, experience having shown that in soft ground such as wet clay or a peat formation, subsidence over any given area is liable to be accompanied by an actual elevation round the perimeter of this area.

Soundings.—Civil engineers adopt a variety of methods in taking soundings, and each engineer as a rule adopts a special method. As a result of experience in trying several methods, the following conclusions have been arrived at:

The survey methods commonly employed are—

(1) Pre-determining landmarks ashore and "lying off" each range with a steel cable moored to the shore and marked at appropriate intervals (two observers).

(2) Using the same procedure as in (1), but avoiding sinkage of the steel cable by employing a buoyed line (two observers).

(3) Taking spot soundings over the area and signalling ashore to two observers each stationed with a theodolite at opposite ends of a pre-determined base line (three observers).

(4) Taking spot soundings over the area concerned and

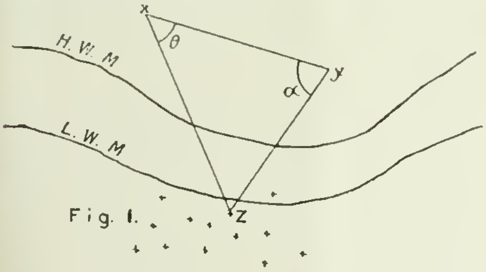

Fig. 1.

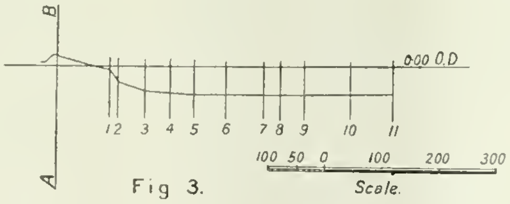

Fig 3.

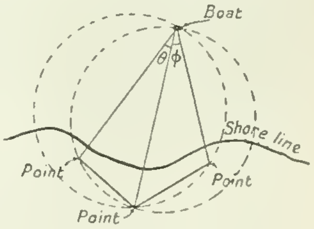

Fig. 4.

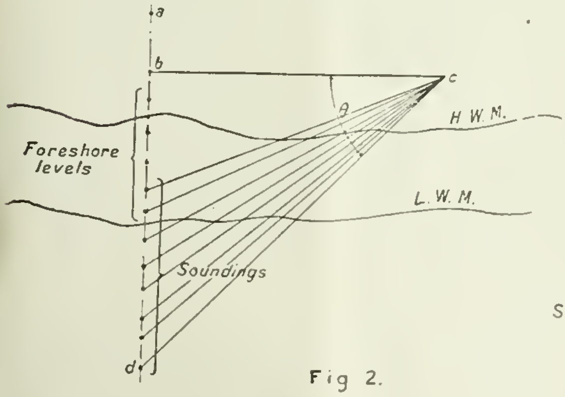

Fig 2.

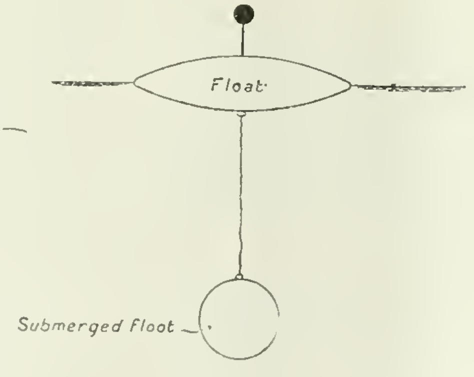

Fig 6.

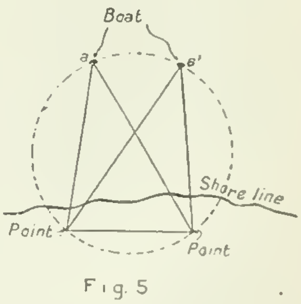

Fig 5

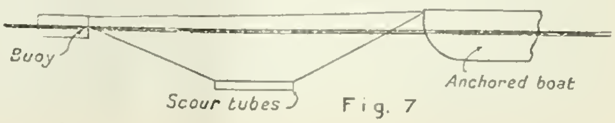

Fig 7

Figs. 1 to 7.—Methods of Making Surveys for Marine Structures.

sextant observations afloat to at least three known marks base line (two observers).

(5) Sextant observations in a boat ranged in on two marks ashore but to a third mark at the end of a pre-determined base line (two observers).

(6) The same method as (5), but observing the angle from the shore by an observer stationed at the end of the base line, i. e., at the third mark (two observers).

The number of skilled observers quoted above is in addition to the observer always required in such surveys for the purpose of reading the tide gauge or otherwise checking the changes in water level by staff and levelling instrument. In some cases this duty can be combined with the other duties of one or other of the observers ashore, but it is in general not a course to be recommended, as it is liable to lead to confusion.

The use of a motor boat, curiously enough, is not an advantage, as craft of this kind are most difficult to hold on bearings, and two watermen, skilled in their craft, and an ordinary open boat, weather permitting, give the best results.

It may, therefore, be taken that for the purposes of securing soundings with any degree of accuracy, a survey party of at least five or six persons is required, including watermen. Taking into consideration the fact that at least two of the party must be trained surveyors, and that work is limited to a maximum of about two hours a day, the expensive character of this work can easily be realized.

In considering the relative merits of the six methods detailed above, it is clear that methods (1) and (2) are liable to be unsatisfactory. In practice, unless under exceptional conditions, the readings on the ranging line will not give the true distance from the boat to the station point ashore. In the case of steel cables the error is principally due to the submergence of the cable, and it is impossible to judge the extent of this error as entanglements frequently occur with obstructions on the sea or river bed. Method (2) is better than method (1), but the slightest wind or tide will "blow-out" the line, which it is impossible to keep taut. These methods can, however, be used if a definite mooring or anchorage can be secured at the sea end of the line, but such precautions are slow, expensive and unduly elaborate.

Methods (3) and (4) are useful where great speed is necessary. The observer afloat with the sounding line can take his observations with extreme rapidity, ignoring his exact location, as the only precaution he has to take is to see that he covers the area with a sufficient number of soundings close enough together to enable contour lines of the sea or river bottom to be established by proportional measurements, made afterwards in the drawing-office. The approximate profile of any desired range can, of course, be established from the contours thus obtained. These two methods cannot be regarded as giving extreme accuracy, as it will be noted that the method of obtaining contours presupposes a constant gradient between any two soundings. Method (3) is preferable to method (4), and is simply illustrated in Fig. 1. The base line x y is established ashore, and while for example the sounding z is being taken, two observers note the angles θ and α.

Experience has shown one very important point, and that is the absolute necessity of arranging beforehand a clear code of signals between observers ashore and afloat. In taking soundings the observer afloat gives the signal, takes his sounding and books a consecutive number. If the sounding is unsatisfactory, he repeats it, but he must re-signal and take his second attempt as a separate sounding; otherwise there is great danger of confusion occurring between the relative soundings and the respective angular observations, and valuable time is wasted.

Methods (5) and (6) are to be preferred, in almost every case, as likely to give the most reliable and accurate results. Both methods are based on the same principle, but method (6) is the best. Fig. 2 illustrates this method. A pre-determined base line b c is established ashore, and the marks a and b erected. The boat is held on the line a b d by ranging b with a. Soundings are taken at frequent intervals by the observer in the boat, and he is able to note any marked changes in depth, so that he can group his soundings close together or at wider intervals as changes in the bottom may indicate as desirable. Soundings are signalled ashore and the varying angle θ observed with a theodolite at point c. In the diagram the angle c b d is shown as a right angle, but the range line may bear a greater or less angle to the base line, provided the intersection of lines c d and a d do not become too acute, thus introducing errors in location. This method has the obvious advantage that the ranges can be carefully selected beforehand to fit closely into any projected scheme of works. Fig. 3 illustrates a profile taken in the manner described, and the table below shows the actual observations made at a recent survey of Horseshoe Bay. The table is useful as giving an illustration of a practical form which the surveyors' field book may take for this class of work.

It cannot be too strongly emphasized that all soundings should be reduced to the level of Ordnance Datum, as cases have arisen in which considerable confusion existed owing to this precaution not having been observed. If soundings are reduced to Ordnance Datum, depths of water can be ascertained against any other desired level, such as the "lowest observed tide," etc. For example, in the case of the Thames Estuary there are the following eight different levels:

H.W.O.S.T.
H.W.O.T.
H.W.O.N.T.
Trinity High Water Mark (12.5 O.D.).
L.W.O.S.T.
L.W.O.T.
L.W.O.N.T., and
The Port of London Authority datum line for soundings (—8 O.D.).

Although there would naturally be no confusion between high tide and low tide, there is ample room for misunderstandings as to their definition.

Current Observations.—This section of marine survey work is required in cases where there is reason to suspect that the construction of new marine works may produce excessive scour, or cause silting and shoaling up in the immediate vicinity. Such surveys are also sometimes called for in dealing with claims cases in the law courts, and for the purpose of determining river or tidal discharges. They are likely to be of some importance in this country in the near future if tidal hydro-electric schemes emerge from their present somewhat visionary aspect into the field of practical politics, as is now the case in France.

Such observations naturally divide themselves into a study of:

(1) Surface velocities.
(2) Sub-surface velocities.

The former may be of some importance when dealing with the berthing of vessels in a tideway, and the latter of importance in so far as they may affect the stability of marine work, or cause interference with the river or coastal regime in the vicinity.

(1) Surface velocities may be estimated by observing the movements of any suitable form of float, either by following the latter in a boat with sextant observations which requires three pre-determined landmarks ashore—see Fig. 4—or, alternatively, simultaneous observations by theodolite at either end of an established shore base line which, as in the case of soundings, is to be preferred. For local surveys of the class under consideration, the necessity of using a sextant afloat is often urged, but this instrument, although useful for nautical observation, is of little value in ordinary marine survey work as practised by civil engineers. It is a common error to assume that a simple observation from a boat of the angle subtended by two fixed points ashore determines the position of the boat. The most elementary problems in geometry show this assumption to be incorrect, e. g., in Fig. 5 are shown two alternative boat positions a and a^1 and there are, of course, many others giving the same sextant reading (i. e., positions on the perimeter of the dotted circle.)

Even with the minimum of three points ashore and two observed angles θ and ϕ as in Fig. 4, the reduction of each observed position to ordinate and abscissa for drawing-office purposes involves a considerable amount of calculation, and it is preferable, therefore, to adopt a base line ashore and follow the movements of the float or accompanying boat by simultaneous theodolite observations, generally on a prearranged time-table. The calculation of each observed position is then simple or equally straightforward if dealt with graphically on the drawing board.

The form of float for observing surface velocities must be such that it is practically awash, and, therefore, not subject to the influence of wind. A small mast must, however, be attached to the float to enable it to be seen, and a small black bulb at its head will be found to afford the best mark for locating. The float should be of large area and only a few inches in draught. One of the most satisfactory methods is to distribute several floats over a small area, and to smother the surface with light colored dust such as powered cork or brick dust, which remains buoyant for some time, and then to follow the floating "field" in a boat which, as an object, is easily picked up by the observers ashore. This method was tried in 1913 by one of the writers on the Burry Inlet, South Wales, with success.

Sub-surface Velocities.—These observations, without doubt, present greater difficulties than any other section of marine survey work. They seldom can be dispensed with wherever it is considered there is any question whatever likely to arise in regard to possible scour or siltage which might be set up by the construction of new works.

One method is for a large submerged float to be suspended from a very small surface buoy, but the observations taken to the surface buoy are not really satisfactory because, no matter how small this buoy, its presence affects the free movement of the submerged float.

Another method, giving better results, is that shown in Fig. 6, where the surface and sub-surface floats have approximately the same mass and wetted surface. Surface observations are first taken with the upper float alone, the lower float or sinker is then attached by means of a light cable or line, and the average velocity of the two floats noted. By adding or subtracting the difference—as the case may be—in the observed velocities, the sub-surface velocity at the level of the lower float can be ascertained. There are some errors, however, in this method since, in the first place it cannot be assumed that the travel of the compound float will cover the same ground as that covered by the travel of the surface float alone and, where the differences in the surface and sub-surface velocities is marked, the exact level at which the lower float is traveling is doubtful.

Nevertheless the above methods are the really only practical ones for determining the travel of currents and their varying velocities at the same time.

The methods for measuring velocities alone, at any given fixed point, consist either of the employment of a current meter or a pressure tube.

The writers' experience of current meters has been unsatisfactory. The current meter in the first place is an expensive instrument and difficult to manage in an open tideway. In seems that its effective use is confined, more or less, to permanent station points in shallow water or in canal or irrigation systems. The calibration curve for such a meter must be taken before any series of observations are made, and there are a hundred and one possibilities of the meter gear sticking or jamming. The question of lubrication, and the class of oil used, also affects the instrument considerably. The use of pressure tubes would be satisfactory for torrential currents, but is of little use for ordinary tidal speeds, as only a few inches difference in level is recorded for a current speed of several miles per hour and, except in absolutely still weather conditions, such small measurements are impossible to read accurately.

The writers have given some thought to the following method which, however, has, it is believed, never been tried, but is put forward for what it is worth.

It is well known that different materials respond to different scouring velocities, and an instrument could presumably be devised by obtaining a number of tubes partly filled with different materials graded from very fine sand up to small pebbles, whose scouring velocities had been previously obtained by laboratory experiment. This instrument could be moored to a boat at anchor, and held at the other end by a down-stream float or buoy, riding at a known distance from the boat as shown in diagram, Fig. 7. The depth would definitely be known and the instrument would take up a true alignment with the direction of flow. The submerged tubes would be opened at both ends by a snatch halyard, or an electric device, and after a few minutes closed again. The instrument on being raised to the surface would then show some of the tubes scoured out and others with material still remaining in, according to the scouring velocity of the current which, within narrow limits, could then be definitely ascertained.

TABLE OF SOUNDINGS IN HORSESHOE BAY.

	No.	Time, h.	m.	Angle.	Sounding. Ft.	Correction. Ft.	Reduced level. Ft., O.D.	Distance out from A.B. Ft.
Line I.A.	1	10	8	13.20	2.5	+4.3	— 6.8	92
	2	10	13	15.20	25.7	+4.0	—29.7	106
	3	10	15	21.20	37.5	+4.0	—41.5	150
	4	10	17	26.20	39.0	+3.8	—42.8	192
	5	10	19	31.00	42.0	+3.7	—45.7	234
	6	10	20	36.40	43.0	+3.6	—46.6	287
	7	10	22	42.00	42.0	+3.5	—45.5	352
	8	10	24	47.40	44.0	+3.4	—47.4	426
	9	10	26	52.20	42.0	+3.3	—45.3	505
	10	10	26	52.00	44.7	+3.3	—48.0	502
	11	10	28	55.40	45.0	+3.2	—48.2	571

Water Meterage at Johannesburg, South Africa

From The Surveyor, London.

In Johannesburg the whole of the supply, excepting fire services, is metered. The position is somewhat unique in that water supplied by the Rand Water Board, which now averages about 4,250,000 gal. per day, is measured by two large Venturi meters, and is then distributed through no fewer than 24,300 meters, the smallest and ruling size being ½ in.

When the waterworks of Johannesburg were taken over from the company in 1905 the charge for water was 10s. per 1,000 gal., plus 2s. 6d. per month for rental of meter. The charge is now 4s. 7d. per 1,000 gal., including the use of the meter. A minimum charge of 2s. 6d. per month is made where services are connected to the town mains but no water used.

Johannesburg Meter Regulations.—The Johannesburg municipal regulations applying to water meters are briefly as follows:

All meters are the property of the council.

They are generally fixed under the street footpath as close as possible to the boundary of the consumer's property, but the owner must provide a suitable and safe place on his own property if required to do so.

Consumers are responsible for safe keeping and condition of meter.

Consumers are not allowed to interfere with any meter or cause any other person to do so.

Meters are maintained and repaired at the cost of the council, except for damage caused by interference or accident.

In case of dispute as to measurement, the council will cause meter to be tested. If found to be correct, the consumer has to pay testing fee of 10s., if not, the meter is corrected and replaced at cost of council.

A meter is taken as correct if error is not more than 2½ per cent either way.

If meter registration is found to be incorrect, the charge is based on previous consumption, and, if no previous consumption, on subsequent consumption.

A stop cock is provided by the council on the main side of every meter.

If account, which is rendered monthly, is not paid within a reasonable period the water is cut off, the charge for reconnecting being 5s.

Portable meters are provided for temporary supplies at the rate of £1 per month, the value of the meter to be deposited and retained until it is returned in good order; if damaged the cost of repairs to be deducted.

Water taken for street watering is calculated on the number of loads used, the vans being supplied with load indicators.

The quantity of water taken from hydrants for fires is arrived at by calculating the discharge through various lengths of hose at different pressures.

When disputes arise as to the quantity of water registered by meters, it is sometimes more satisfactory and convenient to test the meter in situ. For this purpose a portable tank is provided, the capacity being 100 gal. A gauge glass and scale are fixed at the side of the tank which makes it possible to measure any quantity to within a quart up to the capacity of the tank. Care has to be taken that the tank is perfectly level before the test is commenced. One advantage about this method is that it gives the consumer an opportunity of seeing the result under ordinary working conditions.

Domestic Water Waste in England

Sources of Waste, Means Suggested for Checking It, National Loss Estimated at $8,000,000 per Year, Normal Consumption Greatly Below American Standards

By G. R. COLLINSON,

B. S. Assoc. M. Inst. C. E. Water Engineer and Manager, Swansea.*
From the Surveyor, London.

It is unbelievable that anyone would think of advocating the adoption of meters for domestic household water supplies in this country, but the disciplinary effect of charging on the basis of consumption, as is done for gas and electricity, would be a tremendous asset in educating consumers to a proper appreciation of the value of water, if there were not the danger of its necessary and legitimate use being affected.

The questions to which it is desired to direct attention are —(1) What waste of water is there in this country? and (2) Is it an economic possibility to reduce the waste? They involve, first of all, the fixing of something in the nature of a proper standard minimum attainable rate of consumption of water per head, excluding all waste or as nearly so as possible, and it is realized that many eminent authorities in the past have declared that such an empirical standard could not have any wide application on account of the great variations in the conditions appertaining to different localities.

Variable Factors.—The most variable factor of all, however, can be removed if trade and other measured supplies are left to look after themselves, which can very well be done, inasmuch as meter consumers who pay according to quantity may be presumed to reduce the waste in connection with their supplies to a minimum, and by confining any suggested standard rate of consumption purely to domestic and ungoverned supplies. It has also been pointed out many times that the use of baths and water-closets in proportion to population is not the same everywhere, which prevents conditions being comparable, but time and modern sanitary enlightenment have gone a long way towards leveling things up in this direction, at any rate in water-supply areas of any magnitude, where any notable high rates of consumption now call for some explanation other than merely the existence of a high proportion of baths and water-closets. It is found from tests of various localities at Swansea that such a cause alone accounts for a variation of consumption only amounting to about five or six gallons per head per day, and that any greater variation is always capable of some other explanation.

Differences of pressure in the distributing mains of various authorities are also quoted as obstacles in the way of fixing a standard attainable consumption, and, of course, the waste from any given defect certainly does increase with the pressure, being, in fact, proportional to the square root of the pressure, but in arriving at a standard minimum attainable rate of consumption it would naturally be assumed that defects were practically all eliminated, and were not, therefore, capable of greatly affecting the consumption whatever the pressure might be.

It is admitted that a high pressure would hasten the development of incipient defects in weak pipes and poor fittings, and would increase the time and expense required in any particular case to reach and maintain a proper standard, but it need not prevent such a standard being eventually attained. Then it has been stated that effective statutory powers to enforce a high quality of pipes and fittings and to put down waste, are not possessed by all authorities, which prevents the less fortunate ones reaching as low a percentage of waste as in other cases. Experience at Swansea in this connection has shown that the exact legal or statutory form and extent of such powers, however far-reaching they may be, is of less importance than the practical and common-sense manner in which such powers as may be possessed are put into operation, and it cannot be accepted that differences in legislation should have any considerable influence upon the standard minimum attainable consumption. In any event, it should not be difficult to remove any handicap of this kind by obtaining the deficient statutory powers.

Notwithstanding the conditions already mentioned and many others of less importance which have been put forward from time to time, it is contended that some standard minimum attainable consumption for domestic and ungoverned supplies can be fixed to the advantage of everybody, so as to represent a datum which would indicate when everything reasonably possibly in eliminating waste was being accomplished.

If it were attempted to fix the proper standard average domestic consumption of water by estimates of the quantities separately required for sanitary, ablutionary, culinary, and other every-day purposes, probably no two persons would be found to agree exactly, and a less questionable result can probably be attained by a careful examination of figures representing the actual current consumptions within the supply areas of a number of important water undertakings.

A Sixteen-Gallon Basis.—From a list including 21 of the largest of such undertakings, it appears that the average domestic consumption in gallons per head per day falls between 14 and 15 in three cases, between 16 and 17 in five cases, between 18 and 19 in three cases, between 19 and 20 in two cases, between 20 and 25 in four cases, and between 25 and 40 in four cases. The towns showing the lower consumptions are quite representative of the whole, and it seems reasonable, therefore, to assume that 15 or 16 gallons per head per day would be a proper figure to take as a standard which ought to be generally applicable as the minimum attainable consumption for domestic and ungoverned supplies. A figure of about this magnitude has more than once received legislative sanction, and it may be noted in connection with the supplies which other authorities within a mile of the Swansea trunk mains can demand, that Parliament has granted Swansea a prior right of only 25 gal. per head per day, of which nearly 10 gal. is absorbed by trade-metered supplies. If a calculation be made upon the basis of an attainable domestic consumption amounting to 16 gal., there is revealed the startling fact that the enormous quantity of somewhat over 100 million gallons of water per day is wasted in connection with the water undertakings (exclusive of the Metropolitan Water Board) represented within the membership of this association.

It is quite expected that many representatives of important water undertakings will not accept the figure given as waste, or many contend that it is not preventable waste, but if some authorities can get the domestic consumption down to the figures given, it is difficult to see what substantial reason there is why others should not do so, although it is appreciated that the time and expenditure involved in doing it may vary a good deal in different supply areas.

The explanation which is most strongly put forward in this paper as the reason for the striking differences in the domestic and ungoverned consumptions at various places is one quite outside those usually given, and it is suggested that it may be looked for in the varying degrees of keenness, ability and energy displayed by the members of inspection staffs throughout the country. Scientific mapping and zoning of supply districts with the object of avoiding unnecessarily high pressures, installations of waste-detecting meters, provision of outside stop-taps for night testing, regulations to control fittings and many other valuable means and machinery to detect and prevent waste, are now liberally provided on what are almost standard principles nearly everywhere, but the personal factor counts most of all, and is the most likely explanation of the discrepancies in results.

Testing for leakages by night and day, especially when they are underground and out of sight, and the laborious inquiries entailed with regard to ownership and responsibilities where complicated joint supplies are concerned, demand a high level of intelligence and zeal on the part of an inspector, whilst the energetic and persistent pursuit of the same sort of leaky taps, leaky cisterns and burst pipes day after day becomes a dreary monotony which calls for unusual patience and determination if constant, steady progress is to be made, and the value of a well-trained and carefully-built-up inspection staff in connection with any water undertaking cannot be overstated, whatever methods and appliances for the detection and prevention of waste are adopted.

It is believed that if more pains were taken in the selection and training of a sufficient number of waste inspectors of the highest possible class all over the country, the chief difficulty which stands in the way of an all-around approach to some such standard of attainable consumption as has been suggested would be removed.

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*Extracts from a paper entitled, "Anti-Waste," presented at a Conference of the British Waterworks Association, held in connection with the Public Works Roads and Transport Congress.

The Economic Aspect.—The question as to whether it is an economic possibility to reduce the waste already referred to necessitates inquiry in the first place as to the value of the water wasted. At the rate of 1 shilling per 1,000 gal., which is not extravagant in these days, and has recently received legislative sanction, the value of the 100 million gallons of water per day estimated as being wasted would be £1,825,000 per annum, and this is approximately the revenue it should eventually produce as time goes on and the water is required for consumption. Such a sum would pay several times over for all the waste detection and prevention work that is now carried out, and even after allowing the most liberal amount that could conceivably be required in adopting any extra measures necessary, there can be no doubt whatever that the salvage of this enormous wastage of water would be a handsomely paying proposition to the water-supply industry.

Application of Liquid Sludge to Farm Land

By ROBERT EATON,
Sewage Works Manager, Blackburn, England.

From The Surveyor, London.

The Samlesbury estate of the Blackburn Corporation was acquired for the purpose of the disposal of sewage by broad irrigation, and in the first instance had an area of 510 acres. About 400 acres only were suitable for irrigation. This area was supplied with screened settled sewage through a 21-in. diameter cast-iron pipe. At convenient places 6-in. iron pipes branched from the main to distributing manholes about 2 ft. square which were supplied by 6-in. control valves.

The land, being chiefly stiff clay, was soon found to be inadequate to deal with the whole of the town sewage, and 4 acres of contact beds were completed about the end of 1903. Since then detritus tanks, septic tanks and percolating beds have been installed. A sludge pressing plant, including eight 40-cell presses, was put down in 1897.

The pressing plant worked well until humus tanks were put into use. Humus sludge from the Dortmund tanks when mixed even in small proportion with the other sludge, proved very troublesome. The presses were put on continuous running day and night, and failed to cope with the work. The addition of lime in large quantities gave only partial relief.

During August, 1909, experiments were commenced so as to find if the sludge could be dealt with on the land. First of all a level field was chosen and the land drains overhauled. The wet sludge was broad spread over certain areas, in other portions trenching and lagooning were tried. These experiments were easily arranged owing to old irrigation pipes being convenient.

The results were encouraging, for the areas absorbed large quantities of sludge. It was then decided to connect the rising main of the humus sludge pump direct to the 21-in. diameter pipe. Then followed an immediate relief in the press house, and day work alone was again sufficient. After a trial of twelve months results were so favorable that steps were taken to prepare other areas. The pressing plant was put on shorter working time, until it was proved that sludge pressing could be abandoned. In 1918 the plant was disposed of at a higher price than the original cost.

Method of Applying Wet Sludge.—The existing irrigation system is used, but the main, having a diameter of 21 in., is much too large for the best working conditions, as it acts as a settlement tank and requires flushes of sewage to drive the sludge along. A main, 9 in. to 12 in. in diameter, should be quite large enough especially if worked in conjunction with a pump. The sludge flows from the distributing manholes along contours and grips, and a clod put into position will serve to divert the flow.

Four sludge men are usually at work and have each a spade and a long-shafted wooden squeegee. They are provided with high-leg, water-tight clogs, and they deal with 200 tons of sludge a day. Three men do the grip cutting and spreading of sludge and afterwards replace the turf; the fourth man supervises and is responsible for the condition of the effluents entering the streams. There are certain permanent contours in every field, and these the tenant farmer is under obligation to open out or prepare.

As sludge is much sought after, the tenants are always ready to assist in the cutting of auxiliary contours, but all the replacing is done by the corporation workmen.

No matter how uneven the ground surface may be, the sludge can be spread over the area fairly uniformly. We do not sludge over main land drains or on the edges of cattle drinking ponds.

Control of Effluents to Streams.—Effluents from first contact areas may at times require further treatment before entering the streams, and measures taken allow us to broad irrigate such effluents a second and even a third time on the lower levels. The arrangement is as follows: Shallow brick manholes are built over the main land drain and the drain relaid close to the surface as it enters the manhole. The drain is thus relieved of pressure and the new manhole is used to distribute the sludge effluents over the adjacent area.

The direct way from manhole to stream is blocked during sludging. When the work is finished the land drainage is permitted to run direct to the stream in the ordinary way. Unfortunately, it is not always possible to plant a shallow manhole in the right place. It has been convenient in such cases to dam up a small stream receiving land drainage and divert the first irrigation effluent over a suitably placed plot below. One such dam is of concrete 4 yds. wide and 3 ft. high. This dam has allowed us to deal a second time with the drainage from about 50 acres, and at a much less cost than by building distributing manholes.

The available area of farm land (chiefly grass) being extensive, there is no need to give overdoses. Usually no plot is sludged oftener than once a year. The objects aimed for are equal irrigation and effective control of effluents.

The Samlesbury sewage farms grow heavier crops and win earlier harvest than those surrounding, without the cost of carting and spreading manure on the fields.

Wet weather and the time just before hay harvest sometimes give a little trouble. Wet weather, because of the risk of fouling the streams—as the newly distributed sludge may be washed off the fields, and during early June, owing to scarcity of available or suitable fields, certain tanks may not be cleaned within their usual period. However, we usually reserve areas for summer sludging, and seldom need to put the farmer to inconvenience or spoil his crop.

Samlesbury sewage farms are let to tenants in eleven holdings in the ordinary way. The corporation do no farming, but reserve the right to irrigate at their convenience. The arable land may be given farm or other manures according to the nature of the crop carried, but grass does well without. A top dressing of lime every few years, however, is a help. There is no revenue from the process; the tenant farmers pay the average rent of the district.

Though the Blackburn Corporation is most favorably placed in owning sufficient land for a cheap and efficient method of sludge disposal, there must be many authorities who, while not owning sufficient land, have their disposal works lying in the center of farming districts. Such works may possibly be able to discharge wet sludge on adjacent farm land by the assistance of a sludge pump and a movable pipe line. The works of the Wolverhampton Corporation have such a pipe line, which can be laid at the rate of 400 yds. per day.

Summary.—(1) The method is cheap and effective. (2) Will deal with activated sludge just as easily as with the different tank, septic or humus sludges. (3) The sludge with its manurial value is returned direct to the land at one operation, which after thirteen years shows no signs of ill-effects from such treatment. (4) There are no complications arising from the use of machinery.

Last year, 1921-22, 36,000 tons of wet sludge were irrigated over the farm land, or, roughly, 100 tons per day. Now 300 acres are more than equal to deal with this quantity, but much of the estate is not suitable for the direct application of sludge, so that an additional 60 acres have been lately acquired, making the total of 570 acres.

Thirty-six thousand tons on 300 acres correspond to 120 tons per acre, and equals 26,880 gallons per acre, which is a little over 1 in. over the surface. One inch of rain equals 22,620 gallons per acre.

Our population is estimated at 133,000, and the labor charges 1921-22 for sludging and repairs to drains were £546 and £224 respectively, total £770.

The inclusive labor costs for sludging per ton of wet sludge works out at 5.13d.

The inclusive sludging costs per annum per head of the population were 1.4d.

Methods and Cost of Mechanical Cleaning Filtering Media of Sewage Beds

By J. H. ABBOTT, Engineer and Manager Chiswick Sewage Disposal Work.

From Municipal Engineering and The Sanitary Record, London.

Those who have charge of sewage filter beds of the contact type are well acquainted with the necessity for cleaning the material in them after a prolonged period of service. It is also becoming the practice to wash and cleanse the material used in continuous filters, although it was at one time advanced in favor of this type of filter that they were free from the defect of sludging up to which contact beds are liable.

Apart altogether from the quality of the tank effluent which the filters are called upon to deal with, this "sludging up" depends a great deal upon the quality of the media used in the filters when this is of a friable nature. The loss of capacity of filters is due to their becoming choked with accumulations of suspended matters brought on to them with the tank effluent, the growth of bacterial slime on the surface of the media, and the gradual disintegration and packing together of the actual media itself.

Prolonged periods of rest in both types of filters to some extent restores the capacity when the loss arises from the two causes first mentioned, and nitrification certainly improves, as much of the organic matter in the interstices of the filter has had time during the rest period to become thoroughly oxidized; but when choking arises from disintegration of the material itself resting the filter is of no use whatever in restoring its capacity.

Such materials as granite, shingle and hard, broken stone suffer hardly any disintegration, but gasworks and destructor clinker, coke and furnace ashes are materials in which the tendency to disintegrate and pack together is most marked. To restore the capacity of a filter, the removal of this disintegrated material is one of the operations which has to be performed as part of the washing process which also removes the sludge.

The media originally composing the filter may vary from, say, 2 in. down to ½ in. gauge, and, in the case of the more easily disintegrated materials, it will be found on washing to contain as much as 20 per cent of material below the smaller size—say, from ¼-in. gauge down to mere sand.

The work of grading the material into different sizes is a matter quite apart from the washing, and when this is desired it can be effected in any suitable manner by either rotary or fixed screens, but the removal of material below a certain size which has to be rejected should be done by the washing process direct.

Types of English Washing Machines.—There are two main types of machines commonly used for washing filtering media. First, those employing flat tables or jigging trays and jets of water. Secondly, those consisting of rotary cylinders with a bath of water inside them or revolving in a water bath. The Ogden washer, designed by the late manager of the Manchester sewage works, is of the first type. It consists of a washing tray and riddle with baffle plates, placed at an inclination to the horizontal, to which is imparted a rotary eccentric shaking movement. The fouled material is fed on to this tray and washed with sprays of water which rinse the material and wash away the sludge. The cleansed material then passes to inclined bar screens, where it is graded to the sizes required.

The Arnold washer is somewhat similar, consisting of an inclined washing tray and screen to which is imparted a simple reciprocating motion by means of a crank. The fouled media is washed with water jets delivered with sufficient force to turn the material over and over as it passes down the screen.

The rotary cylinder type of washer may be divided into two classes. First, those in which the cylinder is composed of unperforated plate, like the Baxter and the Hardy and Padmore washers. Secondly, those in which the revolving cylinder is made with plates having perforations, or of screens, of which the Hughes and Lancaster washer and the Granule Machine Co.'s washer are typical examples.

Rotating Cylinder Type of the Washer.—In the Baxter type the rotating cylinder is a plain cylindrical tube of unperforated boiler plate set at a slight angle to the horizontal. Fouled material is fed into the lower end of the cylinder, and is caused to advance to the upper end, as the cylinder rotates, by the action of a spiral or worm attached to the inside of the cylinder. Washing water is admitted to the upper end, where the washed material is discharged and flows through the ascending material inside the cylinder, the sludge-laden water resulting from the washing being discharged at the lower or feeding end of the cylinder. An annular band, or rail, encircles the rotating cylinder and carries it on live roller bearings. Rotation is imparted by a spur or bevel pinion engaging with a spur or bevel wheel also encircling the cylinder.

In machines of this type the whole of the material to be washed has to traverse the entire length of the washing cylinder before any of the material which it is desired to discard can be separated. This leads to increased wear and tear of the cylinder. Separation of the small grade material is effected by a screen attached to the cylinder and rotating with it at the upper end.

These machines have to be made strong enough to carry not only the weight of all the material in them, but also the water in which the material is agitated. In consequence, this type of washer has to be substantially built, is somewhat massive and heavy, and the bearings and driving gear are expensive.

A good example of the second class of washer is that made by Messrs. Hughes and Lancaster, as seen working at Chiswick. Their washer consists of an octagonal taper drum of flat steel plates, which are perforated from the larger end for half the length of the drum. The plates onwards to the small end are unperforated. The plates are carried by arms attached to a central shaft which revolves and carries the drum with it, the larger end of the drum being immersed in a vat of water.

Fouled medium is fed into the wider end of the drum and propelled towards the narrow or discharging end by means of a worm attached to the inside of the drum. Washing water is admitted at the narrow end of the drum, where the material is above the level of the water in the vat. The material as it leaves the washer thus meets clean water entiring it. The advantage of the perforated drum revolving in the water bath formed by the vat is that the fouled material is agitated in the water bath and is at once deprived of the whole of the fine material which it is desired to reject, the size or grade of this being settled by the size of the perforations in the drum plates. The sludge washed out flows away with the overboard discharge of wash waters from the machine, and the rejected fine material collects in the vat from which it is discharged at intervals by a sluice valve.

Operations in Washing Filtering Media.—Having dealt with mechanical details, I now pass to a broad view of the whole matter of washing filtering media. The process of washing an extensive area of filter beds is one which calls for a good deal of forethought before operations are commenced. The washing process, with a washer of any of the well-known types, is simplicity itself, but the problem of dealing with many thousands of cubic yards of material resolves itself into the simple handling of the quantity to be dealt with, the best arrangements of tramway track to suit the double purpose of emptying the filter beds and refilling them, and the disposal of waste products.

The sequence of operations may be thus detailed: (1) The material has to be excavated from the filter bed and transported to the washer. (2) Material has to be fed into washer and washed. (3) Cleansed material has to be conveyed back and tipped into the bed and leveled. (4) Rejected material separated by the washer or screens, which is too fine to go back into the bed, has to be transported and tipped. (5) Liquid sludge removed in the washing process has to be settled and finally dumped. (6) Wash waters, when freed of sludge content, have to be disposed of.

The whole of these operations have to be carried on simultaneously and continuously; meanwhile the sub-drains or tiles on the floor of the filter have to be removed and drainage channels cleared out previous to refilling the filter with washed material, and the portable tramway track shifted as beds are emptied or refilled.

The Work at Chiswick.—Some idea of the size of this job at Chiswick, where the works are only small, is given by the following figures: Total amount of material to be removed, washed and replaced, 17,660 cu. yd., covering an area of 3¼ acres: the amount of grit and rejected material to be disposed of, 4,000 cu. yd.; sludge produced, 3,900 cu. yd; hourly flow of wash waters, 6,000 gal.

The selection of a suitable site for the washer, taking into consideration the distance material has to be moved, and the question of levels or gradients, is most important. The use of a portable washer may lead to considerable economy in this direction. Tank effluent as it passes on to the filters is generally used for washing, and can usually be supplied by a pipe line and pump. Where a considerable area of land is available, the simplest way to dispose of the sludge and rejected material is by means of lagoons, as in ordinary sludge-lagooning operations, but these materials will probably have to be subsequently removed.

For transporting the material in medium-sized works, portable narrow-gage track of 18-in. or 24-in. gage is convenient, with rails weighing 14 lb. to 16 lb. per yard, and ½-yard or ¾-yard Jubilee wagons pushed by hand. In smaller works, wheelbarrows are used, and in larger ones, wagons hauled by internal combustion or steam locomotives. Aerial ropeway transporters, elevators and other mechanical devices may conveniently be used where the features of the site or the magnitude of the job justify the necessary capital expenditure on plant.

At Chiswick, seven Jubilee side-tip wagons are in use, and about 400 yd. of tramway track with numerous right and left-hand and symmetrical switches and diamond crossings for turn-outs and passing places on the track.

The washing machine at Chiswick is of Messrs. Hughes and Lancaster's make. This washer performs its work excellently, and there is no question whatever that the material is thoroughly washed and comes out clean. The time taken by the material in its passage through the washer is under 30 seconds. The makers state that this machine is capable of dealing with 4½ cu. yd. of fouled material an hour, but we have been able, on the average of a full week's work, to deal with 5¾ cu. yd. an hour, producing 4¾ cu. yd. of washed material per hour, thus showing 21 per cent over the makers' guarantee. Our machine is driven by a 5 brake horse-power Petter Junior oil engine running on paraffin. The engine also drives the 2-in. bore centrifugal pump supplying the wash water.

When disintegration has been considerable, not only is the actual yield of washed clinker less compared with its bulk in the bed in its unwashed state, but the amount of residue or rejected material is also larger and its disposal involves greater cost. At Chiswick this residue amounts to about 20 per cent, and owing to the cramped nature of the site, its disposal is difficult and expensive. Our costs for washing clinker, including all labor in handling the material and disposal of sludge and rejected material, track laying, cleaning up filter bed floor, levelling off washed clinker refilled in bed, engine driver's time, oil, petrol and paraffin for the engine, and repairs, is 5s. 11d. per cubic yard on the material as it comes to the washer, or, allowing for the loss due to rejected material, 7s. 1d. per cubic yard for the finished washed clinker replaced in the beds, including all the above charges.

Novel Form of Pier Decking

From The Times Engineering Supplement, London.

A concrete pier in a part of Manila Bay, where exceptionally heavy seas prevail at certain periods of the year, was constructed with a special form of open decking, as an ordinary solid deck was considered unsafe. The structure, which carries two railway tracks, consists of reinforced concrete beams founded on pre-cast concrete piles. It comprises an approach 400 ft. long by 21 ft. wide, terminating in the pier head 160 ft. long and 30 ft. wide, the decking being 12 ft. above sea level. The piles in the approach portion were driven in two rows under the center of the railway tracks, those in the pier head being in three rows to provide for the increased width. The piles are connected longitudinally by T-beams of width sufficient to carry the railway metals, and the rows of piles are connected transversely by cross girder pile caps. The T-beams are wide enough on the outer side, in each case, to constitute a gangway, but apart from them the pier framework presents a series of openings to the sea below. For the convenience and safety of those using the pier, the openings are covered by a decking of 3-in. planks, merely held down by its own weight, so that it can be lifted and washed overboard by heavy seas.

The prudence of this form of design has been fully demonstrated by the successful manner in which the pier has withstood the destructive typhoons prevailing in the China Sea. Many times the timber decking has been partly washed away, thereby saving, at some cost, it is true, the disastrous effects that would have resulted if fixed decking of the usual kind had been adopted. The general principle underlying this design had previously been embodied in the marine promenade at Burnham-on-Sea, where openings fitted with cast iron gratings were provided as vents for sea water and compressed air beneath the decking.

A New Form of Hydraulic Ram

On June 12 there was a demonstration at Carshalton of a new form of hydraulic ram, devised by T. G. Allen, of Allen-Liversidge, Limited, 106 Victoria St., Westminster. As in the case of the ordinary hydraulic ram, the object of the apparatus is, by making use of a low fall, to raise water to a height considerably greater than the available head. The principle involved will be readily understood on reference to Fig. 1. Here B represents an open tank placed at the top of a weir and communicating with the water above the weir. At half the height of the available fall there is fixed a closed tank A, which communicates with B through the pipe G, and with the tail race by the siphon pipe H, the upper bend of which is at nearly the same level as that of the water above the weir. On the pipe G there is a valve W controlled by the balanced lever V. To start the apparatus, this valve W is opened and water accordingly flows into A, forcing the air there up the pipe F. Hence, any water which may be in the closed tanks C will be forced up into the open tanks D and E from which it cannot return. When the chamber A is at last completely full, the water in the siphon pipe H rises above the bend and primes the siphon. The consequent discharge impinging on the impulse plate carried by the lever V, moves it so as to close the valve W. The siphon continuing to run, a vacuum is created in A and in the pipe F, and the closed chambers C. Water is accordingly sucked up into these chambers through the pipes T. When the chamber A is empty, the discharge from the siphon ceases, and the balance weight pulls over the lever V and opens the valve W, thus starting a fresh cycle. It will be seen that the apparatus, to which the makers have given the name "hydrautomat," differs from the ordinary hydraulic ram, in that its one valve is not subject to shock, and no high pressures are anywhere generated. On the other hand, as the total lift has to be divided up into steps, each rather less than half the height of the total fall, much more piping is required than with the ordinary type of ram, and moreover at each stage an open and a closed tank has to be provided. It will be evident from a consideration of the action of the apparatus, that, if required, a fall of dirty water can be utilized to lift clean water from another source.

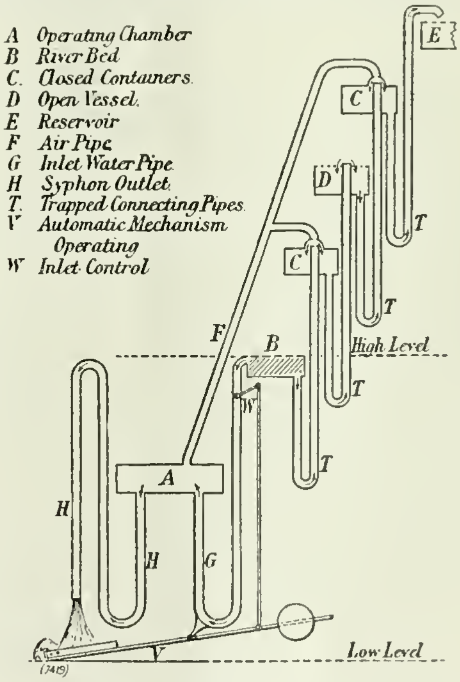


Fig. 1.

307 Ft. Span Concrete Bridge on Danish State Railways

From Concrete and Constructional Engineering, London.

Especial interest attaches to a railway bridge over the valley of the Ore because its main arch is no less than 93 ft. high and 307 ft. between the abutments, and so is one of the largest spans ever built in reinforced concrete. The difficulty of the work was greatly increased by the unusual height of the permanent way—about 133 ft. above high-water level—and by the rapidity of the current of water. The great depth of the valley necessitated a bridge of unusual length and the total length when finished is 630 ft.

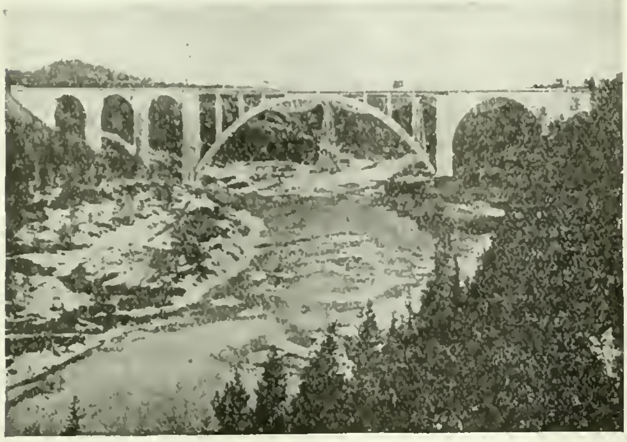


Fig. 1—General View of Bridge.

The bridge consists of the large center arch, which is its chief feature, and four smaller arches, of which three are on the west and one on the east bank of the river.

The central arch was made in three pieces, united with hinged joints. Each section is 8 ft. at the center and decreases to 5 ft. thick at the hinges. These consisted of five sets of cast steel bearings with plates 2 ft. 6 in. wide by 4 ft. 6 in. long against the concrete, the five bearings being connected with a tie-rod 23 ft. long and 3¼ in. diameter. The wooden centering for the arch was built on four large piers of wood, the struts being tied from one pier to another at a height of about 45 ft. On the platform thus made, the rest of the centering of the arch was built in the customary manner.

At the crown, the central arch is 17 ft. wide and it gradually increases to 24 ft. 6 in. at the abutments. The thickness of the concrete at the crown of this arch is 4 ft. 6 in.

The reinforcement consisted of 64 1-in. bars in the center of the arch and 40 bars at the ends, in addition to the stirrups of ⅝-in. round iron placed 2 ft. apart and rather farther apart at the hinges. The arrangement of this reinforcement calls for no special comment.

The concrete consisted of 1 part of cement, 3 parts of sand and 4 parts of broken stone in the main arch, but above a concrete composed of the same materials in the proportions 1:6:8 was used and for the abutments an average of 1:5:7 was employed. The ratio of steel to concrete is 0.1 per cent.

The main abutments are 16 ft. deep and 26 ft. wide and 134 ft. high; they are reinforced with old rails. To ensure stability, each abutment rests on 332 concrete piles each 1 ft. square and capable of carrying a dead-weight of 34 tons. The abutment on the east bank rests on similar piles, but those on the west bank are built directly on the ground as the foundation on that bank were considered sufficiently good.

The subsidiary arches call for little comment, as they do not present any special features.

The permanent way is supported by plate girders of 30 ft. span, securely anchored to the concrete and provided with hinges like the latter.

After the bridge was completed it was left for a year in order that the cement might set properly, as it was thought necessary to avoid all risks with so large a span. Before being used, it was tested by running two heavy locomotives and five extra heavily loaded trucks. The deflection during the trials was 0.4 in. and the permanent set 0.06 in., which may be regarded as wholly satisfactory.

The cost of the bridge was $379,000, and in addition to this the cost of railway diversion and auxiliary work must be added, bringing the total to close upon $534,000. The main arch cost $141,000, of which $38,800 represents the actual concrete work, $8,750 the hinges and the remainder the cost of the wooden centering under the arch.

New Ocean to Ocean Railway in South America.—Construction of a railway which would connect the Pacific ocean with the Amazon River, serving the republics of Ecuador, Columbia and Venezuela on the north and Peru, Bolivia and Brazil on the south, is involved in a concession which has been authorized by the Ecuadorean government. Authority for construction of the railway, according to a Chilean weekly, was obtained from the government at Quito by Ignacio Leon, former Chilean diplomat, for a syndicate capitalized at $25,000,000, members of which include many prominent Chileans.

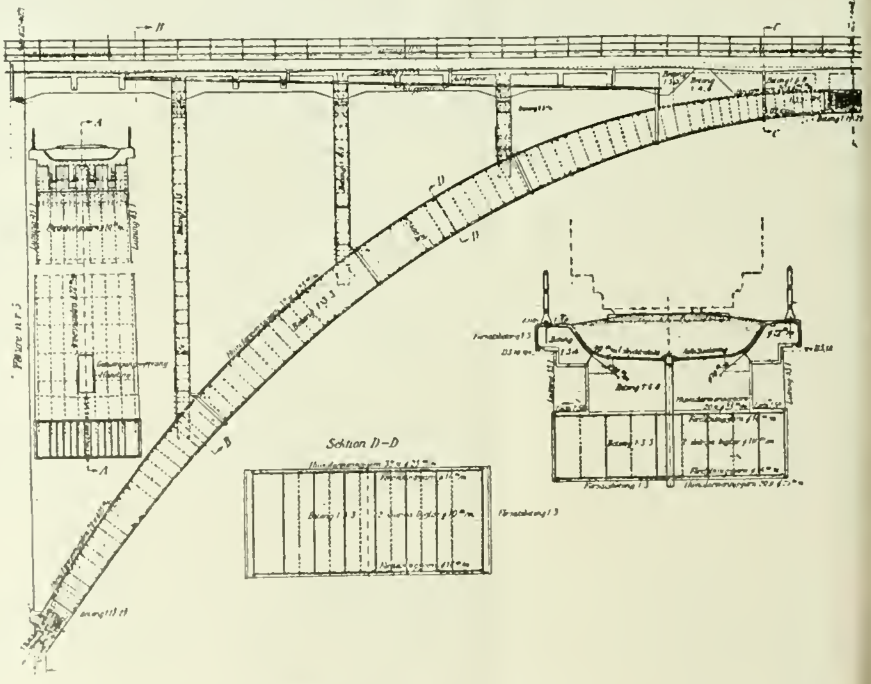


Fig. 2—Details of Main Arch.

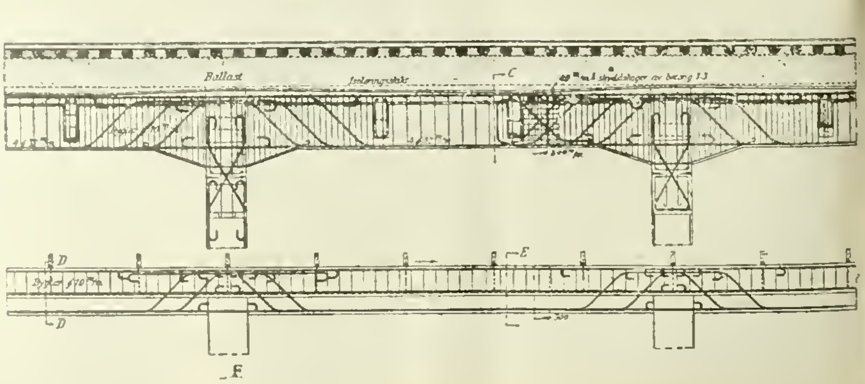


Fig. 3—Reinforcement of Permanent Way.

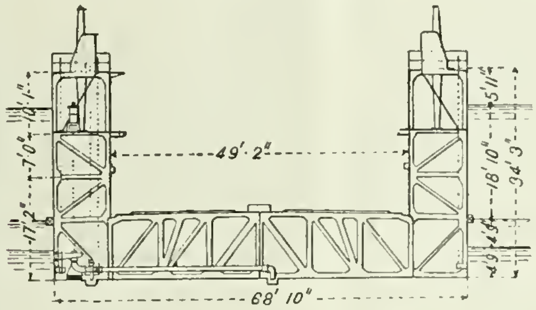
A Reinforced Concrete Floating Dry Dock

From Le Génie Civil, Paris, France.

The 2000-ton reinforced concrete floating dry dock which was recently completed and launched by the Cooperativa Edilizia della Regione Guilia at Trieste, will supply docking accommodation at that port for the larger proportion of the ships engaged in the Adriatic trade. The dock, which presents some interesting features in its construction, has the following general dimensions:

Overall length, including ends	210 ft. 6 in.
Length of body	171 ft. 1½ in.
Overall breadth	68 ft. 10 in.
Breadth, internal	49 ft. 2 in.
Overall height	34 ft.
Height, internal	23 ft.

The general construction of the framing of the pontoon and walls is shown in the accompanying illustration. The transverse frames are spaced at a distance apart of about 3 ft. 4 in. and are tied by the longitudinal members of the upper and under decks and the inner and outer walls. The pontoon of the dock is subdivided into six watertight compartments by means of one longitudinal and two transverse water-tight bulkheads, and each of the lateral caissons is further divided by two vertical walls and braced by diagonal struts. The same construction is adopted in the side walls, with the exception that the upper section is left clear and is provided with windows in the outer wall. The space thus enclosed is utilized to house the motors for driving the pumps and also to accommodate the repairing shop.



General Construction of Framing of Pontoon and Walls.

The dock is furnished with four 3-ton cranes, which are placed at the four ends of the top wall and serve the workshops and the ship in dock. It will be noted that the pumps are placed in the lower compartment of the caisson and that connection is made to the various dock compartments by pipe lines, the vertical spindles driving the pumps passing upwards to the motors in the top compartment. At each end of the dock there is a platform, which extends outwards a little over 6 ft. and is carried by supports.

The depth of steel sections used in the framing vary from 4 in. to 11 in. and the reinforcing material consists of bars from ⅝-in. to 1 3/32-in. diameter. Special reinforcement necessary to meet launching conditions is provided in the upper and lower decks and the walls.

The dock was launched sideways on three launching ways, each about 6 ft. wide, which were built of American pine and space at 52 ft. intervals. Over 20,000 cu. ft. of concrete were used. The total finished weight of the dock, including the machinery, is about 1700 tons, and when empty it floats at a draught of 4 ft. 9 in.

To render the surface of the concrete impervious to water a cement composed of 1 part of Portland cement to 3 parts of sand was laid on by trowel to a thickness of approximately ⅝-in.

This dock is not the first to be built in reinforced concrete. During the last year another dock was built at Minden, Germany, which was about 262 ft. in length, 12 ft. broad, and 10 ft. high, and which is used, not only for repairs, but also for the building of ships up to about 1500 tons weight. In constructing the dock a modified form of the cement gun process was used, the concrete being projected onto thin concrete plates which were previously prepared in moulds.

Completion of the St. Gothard Railway Electrification

From The Engineer, London.

The St. Gothard Railway, 140 miles long, from Lucerne to Chiasso, on the Swiss-Italian frontier, is now completely electrified, and both passenger and goods trains are run by electric traction. On June 1st it was exactly forty years since the line was completed and opened to traffic, and for forty years, therefore, steam locomotives have been used upon it.

When the entire line from Lucerne to Chiasso was still run by steam traction it required about 100,000 tons of coal per annum. This is now no longer needed, all the power required being hydro-electrically generated. Possibly ten years hence Switzerland will have ceased to be dependent on foreign countries for coal so far as her railways are concerned, and already the engineering firms which used to build steam locomotives are modifying their plants for the building of electric locomotives. Moreover, electric traction has been proved by the Swiss to bring about considerable saving in the expense of running a railway, even now, when coal is approaching pre-war prices, instead of being, as it was for a time, five and a half times above them—up to as high as 243f. a ton, in fact. Apart from the saving, however, and the other advantages which passengers derive from electric traction, not only is the journey between Lucerne and Chiasso shortened by one hour—being now four hours by express train, instead of five hours—but the smoke nuisance, which was a positive plague on the St. Gothard at one time, has, of course, entirely disappeared. Instead of having constantly to open and shut the windows because of the many tunnels, they can now be left open even during the main tunnel, which is some 9¼ miles long.

The electrification of the St. Gothard line was begun in 1913, and would probably have been finished by 1916 had it not been for the war, which made the procuring of materials and labor extremely difficult. As is well known, tunnel workers, quarrymen, blasters, etc., are in Switzerland mainly Italians, and they, during the war, had to perform military service, while many of the Swiss engineers, instead of attending to railway electrification, were engaged in patrolling the frontiers. Moreover, it was difficult to obtain electric plant, especially copper cables, which since the Armistice have been acquired from the United States.

The continuation of the line, if it may so be called, 62 miles in length, from Lucerne to Basle, will be ready for electric traction in 1924, and another line, that from Lucerne via Zug to Zürich, a distance of 35½ miles, should be electrified by the beginning of next year. All this railway system of 250 miles is to be fed with electric power from the Ritom and Amsteg power stations, assisted by a smaller station at Göschenen. Ritom and Amsteg together will be able to supply fully 30,000 horse-power throughout the year, independently of fluctuations in water supply.

The 15,000-volt current generated by the Ritom, Amsteg and Göschenen power stations is transformed to 60,000 volts in order to be transmitted to substations, of which there are five between Lucerne and Chiasso and three more for the main lines mentioned already. Those on the Lucerne-Chiasso or St. Gothard lines have all the apparatus and machinery housed in buildings, while the other three are open-air stations.

The maximum gradient on the St. Gothard line is about 1 in 4, and on the inclines the speed will now be 40 to 44 miles per hour; while on the level it will be 56 miles per hour in the case of expresses and 28 in the case of goods trains. The original cost of constructing the railway was 271,000,000 gold francs—£10,840,000—but the electrification of the line from Erstfeld to Bellinzona alone, including the great tunnel, cost nearly 100,000,000f.—£4,000,000 at normal exchange—and it is at present difficult to ascertain exactly how much the entire electrification of the line has cost. According to the estimate of a Swiss engineer, Herr Brack, formerly manager of the North-Eastern Railway of Switzerland before the main railways were nationalized, the cost of the St. Gothard electrification will amount to about 1,000,000f. per kilometre, or about what the line originally cost to build. It is officially stated that the electrification of the Swiss Federal Railways up to the end of 1921 had cost 175,260,363f. for constructional work alone, and another 68,605,419 for electric locomotives—altogether 243,865,782f., or, at the present rate, considerably more than £10,000,000. Each electric locomotive costs some 1,000,000f., or about double what it would have cost before the war.

Besides the St. Gothard line, the Federal line between Simplon Tunnel on the Italian frontier and the Vallorbe Tunnel on the P. L. M. Railway (French frontier) is being electrified, and the work ought to be completed by 1924. Possibly, considering the amount of capital involved, the results once hoped for from electrification will not be so good as was anticipated, and will not greatly tend for some time to lessen the indebtedness of the Swiss railways. Since 1911, however, it has been proved that the electric energy used by the Lötschberg Railway has cost only about two-thirds of what steam traction would have cost.

The Indian Railway Gauge Problem

By FREDERICK GEORGE ROYAL-DAWSON.

Abstract of a paper read before the Institution of Civil Engineers, London.

After 70 years of general railway development in India, the gauge problem still awaits solution, owing to the absence of a definite or consistent gauge policy in the past.

Brief History.—In 1851, when railways were about to be introduced in India, 5 ft. 6 in. was adopted as the standard gauge, in preference to the English 4 ft. 8½ in., as affording greater stability than the latter; and the importance of uniformity of gauge for all Indian railways was insisted on.

In 1863, after about 5,000 miles of railway had been constructed on the standard gauge with English capital on a sterling guarantee of 5 per cent, the Government of India decided that, having regard to the costly nature of the original lines, bona fide feeder lines or tramways might be constructed on a narrower gauge as a temporary expedient, to be replaced by standard-gauge lines when justified by traffic development.

In 1869, owing to a demand for an extensive programme of railway construction on a cheap basis, the metre gauge was introduced as a permanent supplement to the standard or broad gauge, on the understanding that the gauges would be confined to definite areas, and that there should be no competition nor overlapping of interests.

In 1889, in view of the expansion of the metre gauge, a committee of railway men recommended that that gauge should be restricted to definite areas, also that feeder lines should be constructed on the same gauge as the parent line, but that anything of the nature of a link connecting with broad-gauge railways should be either constructed on the broad gauge, or so constructed as to be easily converted thereto. These principles have, however, not been adhered to, the result being that at the present time, with a broad gauge mileage of 18,000, and metre-gauge mileage of 15,000, not to mention 3,500 miles of narrower gauges, there is no longer any serious attempt to restrict the gauges to particular areas or spheres of influence.

Facts and Figures.—While the railways of India, treated as one system, yield a net return of 6.8 per cent, the broad and metre-gauge systems separately yield 6.9 in each case, while the narrow gauges return 3.3. The ratio between capital expenditure and gross earnings is shown to be almost identical on the broad and metre gauges, thereby suggesting that the ultimate outlay on a railway is determined more by its earnings than by its gauge.

Analysis of Capital Cost.—The items of capital cost are divided into groups, which may be classified as follows:

Group I. Items depending chiefly on the gauge, viz., (a) permanent way; (b) ballast.

Group II. Minimum first equipment of rolling stock for light traffic.

Group III. Items depending chiefly on growth of traffic, viz., increase of rolling stock; (b) improvements or developments of fixtures over and above the minimum provided in Group IV.

Group IV. Minimum equipment of fixtures, practically independent of gauge.

Group V. Items necessitated by engineering considerations practically independent of gauge or traffic, viz., (a) formation, (b) tunnels, (c) bridges, (d) training works.

Data are given with reference to the above groups, from which the estimated cost per mile of a single track of railway on any gauge can be depicted graphically for various scales of traffic earnings. Such a diagram shows clearly that when the following two conditions are fulfilled, viz., (i) very light traffic, (ii) exceptionally easy country, the narrow gauge has a decided advantage over broader gauges until the traffic earnings reach the capacity of the single track, when the advantage disappears, for the railway is then faced with the alternative of either doubling or converting to a broader gauge. The diagram also shows that when the sub-grade works are heavy, the advantages of the narrow gauge as regards first cost are insignificant.

The paper shows that economy of first cost is not everything, and that the following gauge characteristics are important factors.

Potential speed is shown to be practically proportional to gauge, and although the average speeds attained in practice are not as great as they should be for the metre and broad as compared with the narrow gauges, there is still a difference in favor of the broader gauges.

Working Expenses.—It is shown that for similar average earnings per mile per week the ratio of working expenses to earnings increases as the gauge decreases, also that as the earnings increase the ratio of working expenses to earnings on any gauge has a tendency to decrease till a fairly constant ratio is reached on every railway. Tables based on the above principles are given in the paper, and other tables show how, for given earnings the higher working expenses of the narrower gauges operate against their cheaper first cost from the dividend point of view, as compared with the broad gauge.

Factors of the Problem.—The inconclusive nature of previous discussion is attributed to imperfect understanding of the problem, or to the issues being confused. The merits and demerits of former arguments are discussed, including (a) alleged unproductive expenditure of conversion; (b) alleged economy of doubling in preference to conversion; (c) alleged inconvenience of conversion; (d) alleged economy of cheap initial cost; (e) alleged inefficiency of broad gauge running dimensions as compared with those of narrower gauges.

Point at Issue.—The point at issue is shown to be, not the comparative merits of the broad and metre gauges, but the magnitude of the evil of break of gauge as compared with the cost of remedial measures.

Inconvenience of Break of Gauge.—This is shown to be not confined merely to handling charges for goods transhipped (equivalent to a few miles of extra haulage as assumed in previous discussions), but to relate more particularly to the serious detention of rolling-stock at every point of transhipment, implying locked-up capital, also to the damage and loss by theft of goods in transit at every point of transhipment, giving rise to troublesome claim cases. It is shown that the gauge question concerns the general public more than the railways, for from the profit-earning point of view a railway on almost any gauge will earn good dividends if properly managed.

An argument against conversion is that it prevents money from being available for new lines, as to which the author's opinion is that the best public interests would be served by making the existing railway system as efficient a transportation machine as possible, rather than by making a fetish of mere mileage progress.

Another argument against the elimination of the metre gauge is that the effect of such elimination would be to stimulate the growth of 2-ft. 6-in. and 2-ft. gauge lines, and that narrow-gauge lines would thus form the nucleus of a system which might in a few years be as difficult to deal with as the metre gauge. The author's reply to this is that the narrow gauges have their own limitations as regards capacity and speed, and that consequently they will never rival the broad gauge, the tendency being to convert to the latter as soon as traffic conditions justify such conversion.

The diagram given in the paper, however, shows that there is a distinct field of usefulness for cheap narrow-gauge lines in easy country when the traffic prospects are uncertain, and that such lines would supplement broad-gauge lines until the earnings justified conversion thereto.

Mechanical Vehicles and Road Surfaces

From Engineering, London.

The cost of transport affects the condition of every country, and the cost of almost every article produced and consumed in it. Bad roads add to the cost of transport, and are a burden on the owners of vehicles though they do not always realize the difference in the cost of operation, maintenance and repair of their vehicles when used over good and bad roads respectively. The larger transportation companies are painfully aware of the facts, and comparative statistics show that often it would be desirable to abandon altogether certain routes where the roads cause abnormal wear. In other cases it would pay the owners of motor vehicles to combine to pay for temporary repairs, such as the filling up of deep pot-holes till the road as a whole can be repaired by the proper authority. The effect also of the surface over which vehicles pass are not confined to roads, and every locomotive engineer knows the difference which a good or bad road-bed and even or uneven permanent way makes in the cost of locomotive maintenance and repair. It is an interesting fact that it is only during recent years that the close inter-relation between the state of the permanent way and locomotive repair costs have been properly recognized on many of the great railway systems in Europe and America, and the expenditure on the improvement of permanent way definitely reflected in the diminution of engine failures and the locomotive repair bill. It is clear that if this is the case when smooth steel rails are employed as the surface for the steel wheel, the conditions of the road are much more important, when roads and road vehicles are considered.

Effects of Bad Roads on Motor Vehicles.—There are four principal effects of bad roads as reflected in the wear and tear of motor vehicles. There is, firstly, the crystallisation and fatigue produced in all metal structures by constant shocks and vibration as, for instance, by pot-holes, corrugations, uneven stone setts, and other irregular surfaces. There is a definite and ascertainable deterioration of the metallic structure in axles, axle-casings, frame, cardan shaft, steering gear, and other parts of the vehicle specially subject to the road vibration. Most of the shocks, although individually of very short duration as a rule, are at the same time of great intensity in some cases. For instance, an ordinary three-ton motor lorry, weighing with its load about 7½ tons, at 15 m. p. h.—a very ordinary speed—has often to run through pot-holes sometimes as much as 2 in. deep or over corrugations whose wave lengths, if the expression may be used, from the highest and lowest points are generally 9 in. to 12 in. apart. On modern roads there is an almost unyielding surface on the far side of these obstructions or holes for the wheel to strike. The blow at the point of the impact is often in force, as much as three times the weight of the vehicle, and in quite ordinary cases equal to one and a-half to twice its weight, or in the case of the 3-ton load vehicle mentioned an impact shock of 15 tons to 30 tons. This blow and shock has to be taken up first by the tire generally in the case of commercial vehicles made of solid rubber, which unfortunately, after a good deal of use, loses a large proportion of its natural resilience. After the tire and wheel come the springs, comparatively stiff in character in the case of a commercial vehicle, which are compressed and relaxed quickly and constantly. Next in order to share in the shock comes the frame, and eventually the transmission-gear, the engine-bed and engine itself.

In the second place, there is the definite wearing of certain movable parts, which themselves have to move with shocks or vibrations, such as the leaves of the springs, the spring shackles and bolts, and wheel brake bands and brake connections. Again, the various rods and the worm-gear connecting the front wheels with the steering gear are in a state of constant movement. In the case of a heavily-laden vehicle, the spring shackles and bolts, unless they are carefully lubricated, show much wear in a short space of time, and when they become worn and loose in their fittings, not only is their wear accentuated, but a disagreeable chattering and noise is set up which, in fact, forms a great part of the noise nuisance which has lately become so serious in the case of heavy commercial vehicles. The body work is also strained and shaken over a bad road, and the fitting of doors, windows, and tail-boards affected.

In the third place, a considerable amount of extra power is necessary to propel a vehicle of equal weight and encountering wind resistance at the same speed over a bad road as compared with a good road. The extra power expended is due to the fact that the vehicle and its wheels have to be raised continually many inches or fractions of an inch after falling into every depression; in addition, side lurches produce unequal strains and wear the differential gears. Every form of vibration and uneven motion increases frictional resistance, which is again reflected in the consumption of motor spirit. From tests the author made, in the engine and gears, some time ago with a lorry carrying 3 tons, he is of the opinion that under bad conditions, such as on an uneven and muddy road, the consumption of motor spirit is increased by at least 50 per cent compared with a good hard smooth road. On a road full of pot-holes and corrugations, but with a hard dry surface, the increase in consumption varies from 25 per cent to 30 per cent. Besides the actual expenditure of energy involved by the continual raising of the vehicle, after its fall into pot-holes and hollows, the transmission of power from the engine to the road wheels is interfered with and proceeds in a jerky fashion, which is a contributory cause of diminished efficiency.

Fourthly, in the case of bad roads where the wheel is constantly interrupted in its actual contact with the road surface for fractions of a second owing to bumps and subsequent hollows, there is much extra wear and tear on tires, on account of the tendency to sudden acceleration and deceleration in the rotation of the wheel, driven, as it is nowadays, by considerable engine power. This sequence takes place on every occasion when the wheel is not actually in close touch with the road surface. Again, the blow given to the tread and fabric of the tires by uneven surfaces tend to make them wear out much more quickly, in the case of both solid and pneumatic tires. In the case of solid rubber tires the resilience of the rubber is gradually destroyed. Though pneumatic tires undoubtedly damp down and neutralise small vibrations, and minimise to some extent larger vibrations, a really bad road causes severe strains on the rims, walls, and general fabric of these, and on the air-valves and security bolts, especially if there is any attempt to run at high speeds. Every blow also increases momentarily the internal air-pressure, though the exact increases of pressure are difficult to ascertain or express mathematically. But the author leaves it to the imagination as to what the strain on a pneumatic or solid tire must be when a heavy vehicle, at considerable speed, encounters a succession of blows caused by obstacles, such as the far sides of pot-holes or corrugations in the road. The momentum of the vehicle, calculated in the usual way by multiplying the speed by the weight, is every time checked at the cost of shock and vibration. Probably the pressures in a pneumatic tire rise for a second or fraction of a second to double or even treble their proper or usual amount, and it is conceivable that many of the bursts in the walls of fabric tires and the loosening or bursting of cords in the case of cord tires of the Michelin, Palmer, and other cord types occur when these blows are delivered. In the case of solid tires the wheel of the vehicle strikes with a greater force than with a pneumatic tire against any opposing surfaces, and the tires in this case tend to split longitudinally or are sometimes partially wrenched from the rims.

In addition to these purely mechanical effects of bad roads, there is the considerable extra strain put upon the attention and endurance of drivers of vehicles, as there is a greater tendency to accidents observable in the direction of side-slips, skidding round corners, and failure of steering gear.

Providing for Motor Traffic of Present and Future.—From the foregoing instances of how depreciation is occasioned to vehicles by bad roads, it is clear that well made and smooth roads are of great value to road-users. The direct interest, therefore, of the user of mechanical road transport in the construction and maintenance of good roads is very considerable, especially in a commercial sense. If in various countries the taxes for road improvement placed on motor vehicles were even heavier than they are today, the payers of those taxes would recoup themselves many times over in the consequent saving, were the roads they use put into good condition, and vehicles enabled to run over comparatively smooth surfaces instead of over uneven and rough surfaces which are now only too common.

One therefore comes by natural sequence to the problem of how smooth and strong roads can be provided for the mechanical traffic of today and the future. In the case of the heaviest motor-lorries their hind axle-weight amounts sometimes to as much as 6 tons to 7 tons, while traction engines running at a slow speed are allowed 8 tons on a single axle, by the law as it stands today in Great Britain. A load of 3 tons to 3½ tons on each wheel is possible and by no means rare. Such a heavy load should be borne not only on strong wheels and broad rubber tires, but the wheels should be of comparatively large diameter, say a minimum of 3 ft. or 900 mm., heavily-laden wheels of small diameter being most destructive of road surfaces due to their small bearing surface on the road. But considering the universal tendency today to increase weights carried by each vehicle, the author is inclined to think that the time has arrived when the weights of the heavier road motor vehicles should be borne on more than four wheels. Already certain systems use six wheels, with the power plant separate from the carrying vehicle, and the use of trailers is also becoming more common, which ensures that the weight on any individual wheel is kept within reasonable limits. A further increase in the weight of any vehicle must necessarily bring about the employment of more axles and wheels, as has been found necessary in railway rolling-stock, where the average bogie passenger-carriage of today, weighing between 35 tons and 50 tons, with four wheels in each bogie, has its weight distributed over eight wheels. Consequently the old four and six-wheel railway vehicles are disappearing, except in the case of small four-wheeled goods wagons carrying up to 12 tons only, which are run at slow speeds and for non-bulk traffic, and a few passenger coaches used on unimportant services. But it is an interesting fact in comparing road and railway vehicle practice, that as regards the latter today, the 40-ton bogie-carriage on eight wheels has, theoretically, a load of 5 tons on each wheel, whereas on some road vehicles not enjoying the advantages of a smooth, strong, steel rail the weight is sometimes as high as 3 tons to 4 tons. Considering its form of construction and weaker resistance to shock it is unwise to require a road to bear a far greater comparative strain than is borne by the steel rail. In saying this, the author does not forget that, in the case of locomotives in Great Britain, the axle-load sometimes amounts to as much as 20 tons, or 10 tons a wheel in the recent and more powerful types such as the new Pacific type on the Great Northern Railway, and 19¾ tons in the case of the newest London and North Western Railway locomotives. Weights up to 20 tons have been allowed since the 1908 curve, as it is called, was adopted by the Railway Engineers' Association. But locomotive engineers have been, and are, endeavoring to reduce weight per wheel in order to save expense in permanent way and get greater adhesion.

Good Roads a Matter of Finance.—In conclusion, it must be borne in mind that the problem of making roads strong enough to withstand the increasing strains, to which allusion has been made, is today one of finance, and only in a secondary degree one of engineering. Most competent modern road surveyors and engineers, if given sufficient money, can make a road strong enough to stand almost any strains and its use by vehicles at almost any speed. But to make such a road is very costly, and the expense increases rapidly if heavy weights at high speeds have to be provided for. Already roads specially surfaced cost as much as 15s. or even more, per superficial yard in the case of main trunk roads through country districts, and as much as 30s. to 40s. per superficial yard in the case of much used streets in towns, which are paved with stone setts, wood blocks, or asphalt laid upon concrete foundations. It is clear that in over-taxed and over-rated Europe such a cost cannot continue to be provided except in special cases where the heaviest and most constant traffic exists, and if only these expensive surfaces last for a really considerable period of years during which no repairs of any consequence are necessary. A cheaper form of road-making is therefore very desirable if we are to continue to improve our highways in strength and smoothness, and road traffic is to be worked economically. Any highway engineer or highway construction firm who can lay down a road in the neighborhood, of, say, 5s. per superficial yard for the ordinary main trunk road, will deserve the thanks of all motor-vehicle users, as well as of the suffering tax and ratepayers. The author is inclined to think that most of the present system of road-making by what is known as single or double carpet work on specially prepared foundations is too expensive for our present impoverished state. Economy as well as efficiency will, it is hoped, be secured eventually by some other cheaper process.

Improvements in the methods of road-making and in the diminution of cost are of immense present and future interest to the users of mechanical vehicles, for governments and local authorities are finding it increasingly difficult to obtain money to spend on road improvement and maintenance. It is, at the same time, incumbent on designers and makers of mechanical road vehicles to spread the weight of their vehicles over more wheels if possible, and to limit the total weight borne on each wheel to say 2½ tons as maximum.

The author has shown the cost of bad roads to every owner and user of a road vehicle, and each nation as a whole has eventually to pay more for the extra cost of its transport under such conditions, which in turn increases the price of every kind of article to the manufacturer and consumer. To save this waste there must be more co-operation between road-makers, designers of road vehicles and road users, to promote economy in the upkeep and improvement of roads, which at once reflects itself in cheaper transport. Otherwise the road and the vehicle alike will suffer, and no prudent man can help seeing that there will be increasing difficulty in finding money in the next few years for road construction and repair. Bad and rough roads entail an extra burden on the community as a whole, for which every vehicle owner, road user, consumer and manufacturer, has to pay. Every nation therefore is directly interested in keeping down the cost both of road-making and the use of vehicles upon the road.

Zoning to Secure Amenities

By BARRY PARKER,

From The Surveyor, London.

One thing which most people appreciate which zoning can prevent is the lowering of a whole neighborhood by the introduction into it of one factory, and the depreciation of the value of all the property in that neighborhood due to this. What zoning can secure for factories is room for expansion, transport facilities, whether by rail, road, or water; proximity to sources of power and raw materials, and to markets, exchanges, and labor; together with proximity to interdependent factories.

It is in prescribing the number of houses to the acre, and the proportion of the area of each plot which may be covered by buildings, that zoning can do so much to secure amenities. But what a zone plan may also do by fixing building lines is far from inconsiderable. Absence in the past of the power to enforce a building line has created many of the difficulties met with in American cities. I would not fix these building lines at the same distance from the street throughout the length of a road in every case. I would so fix them that buildings on carefully selected sites should stand in front of, or back from, the general building line.

It is by prescribing the number of houses to the acre that an agricultural belt around a town can be preserved. It has now been proved that it is entirely practicable to enforce the spirit of a regulation which lays down the number of houses to the acre. If it is possible to secure twelve houses to the acre, then it is possible to secure twelve acres to the house (or whatever number may be thought to be right in an agricultural belt) in the same way.

Economies in Railway Maintenance of Way Work

The large expenditure involved on labor in connection with permanent way maintenance and renewal furnishes abundant reason for the careful consideration of any device having for its object the saving of labor. For this reason, developments are proceeding in many directions in the way of introducing mechanical aids to permanent way work. Of late years many ingenious contrivances have been invented for the more speedy and effective performance of work on the permanent way. It is to be noted that, in some cases, these mechanical aids have been invented by working track men, and this would seem to indicate the desirability of encouraging the track staff to extend their work in this direction. On the other hand, the use of electrically-operated machinery is becoming more and more usual, and there can be little doubt that this will continue to advance to the benefit of both the railway company and permanent way man.—Editorial in The Railway Engineer, London.

The Training of a British Highway Engineer

By GEO. S. BARRY, Surveyor of the Ayr District of Ayrshire.

From The Surveyor, London.

The profession of a highway engineer, or road surveyor as it is termed in Scotland, has today attained a degree of importance which it never before held. This is primarily due to the remarkable development within recent years of mechanical transport and the consequent application of newer and better methods of roadmaking and maintenance. Such a development suggests a corresponding development in the administrative and technical aspects of the profession These newer methods have enlarged the experience of highway engineers just as the introduction of the turbine and the Diesel engine did in the case of mechanical engineers.

In by-past years, the vocation of a highway engineer was largely recruited from trades and professions which had only a partial connection with highways. The regularly trained engineer was not very much in demand, mainly because many local authorities did not appreciate the value of a trained man, and seemed to prefer the services of one who invariably had to learn or "grow into" the work.

Today such a condition is unthinkable, and it is now appreciated that a public body pays an official to do his work instead of being taught how to do it. When it is considered how much is embraced by the term "highway engineering," it will be conceded that this occupation now forms a definite and important branch of the broader term "civil engineering." The enormous importance of highway maintenance has brought with it the demand for a specialized knowledge and training as is evidenced by the requirements of the more important local authorities on the one hand and the Ministry of Transport on the other, the latter body having quite recently refused to recognize certain road appointments made by local authorities.

It is becoming more and more evident that the education of a highway engineer must be placed upon a proper basis. So marked has been the development in roadmaking and upkeep that it now becomes necessary to consider what can best be done in this direction. For example, up till about fifteen to twenty years ago it was not essential that a highway engineer should have any knowledge of the principles of chemistry, but today this branch of science takes such a prominent place in his daily work that some knowledge of the chemical constitutents of the various materials he employs and the laboratory tests which are required to determine the most suitable materials for his purpose is essential. The chemical aspect is but one thing. There are others which also demand the greatest consideration—namely, geology and perology, the strength of materials and the theory of structures, to mention only a few, all of which have been more or less neglected in the past so far as highway engineers have been concerned.

The author, therefore, proposes in this paper to outline what he believes to be the modern rquirements as regards the calling of a highway engineer, and suggests the lines upon which these requirements may be fulfilled.

The Office and Its Equipment.—It is not possible for an engineer to tackle his work thoroughly and expeditiously unless provided with the accommodation, instruments and materials which that work demands, any more than a tradesman can turn out good work without the aid of proper tools. There are many offices which are very imperfectly equipped. and much delay and occasional inaccuracy result. Nothing is more deplorable than shoddy work in these days when a high standard of quality is expected by Government and other departments with regard to matters submitted to them. What equipment is actually needed is a question that can only be settled by the nature and extent of the work to be performed, but there are, of course, certain basic necessities which must be met. Ample office accommodation is the first consideration; the furnishings are of next importance, and these should include, among other things, a good drawing table, a nest of plan drawers, up-to-date filing cabinets, a complete set of 6-in. Ordnance survey maps of the district with 25-in. Ordnance survey maps of all the populous places within it, and a 1-in. geological survey map. All surveying instruments should be of the most approved design and by reliable makers. There should be ample facilities in the neighborhood of the office for testing their accuracy and for making any simple adjustments which may become necessary.

It is rather remarkable how many offices are in these days imperfectly equipped so far as drawing instruments and calculating apparatus are concerned. Some years ago it was not the general custom for offices to be provided with drawing instruments, and, in consequence, draughtsmen were, like some kinds of tradesmen, obliged to purchase what apparatus was necessary to enable them to discharge their work. This ought to be a thing of the past, and no office can be considered as adequately equipped unless in possession of a good set of drawing instruments, in addition to a slide rule and a planimeter, as well as the usual parrallel rulers, straight edges, and so on.

Then there is the question of the office library. A representative collection of standard technical works for reference should be in every highway engineer's department. There is quite a large number of excellent books dealing with various branches of engineering, but the author does not propose to mention more than a few which he considers should form part of the office equipment:

A bound copy of Hurst and Molesworth.
Trautwine's Civil Engineer's Pocket Book.
Adam's Building Construction or Mitchell's Building Construction.
Volume 4 of Rivington's Notes on Building Construction.
Wood's Modern Road Construction.
Aitken's Road Making and Maintenance.
Whitelaw's Practice of Surveying.
Ferguson's Law of Roads and Streets in Scotland.
The Councillors' Manual.
The publications of the British Engineering Standards Association relating to road materials.
Highway Inspector's Handbook by Prévost Hubbard.

The author has found these books particularly valuable, and, in addition, he would suggest that some good work on bridge design and construction dealing with the subject in simple and concise language should be included. Further, a good book on field geology is also a recommendation.

Professional papers are indispensable, and so is the journal of the institution. These periodicals provide a regular supply of information as to what is being done by engineers and surveyors in all parts of the country, and constitute a mass of particularly valuable matter. They should be read regularly, and important points digested and noted for future guidance. Moreover, the "Queries and Replies" section of a professional magazine affords a ready means of getting information about any knotty point of practice which may suddenly crop up. The advertisement columns are also of some value in that they bring one into touch with the most up-to-date materials, appliances and methods.

Theoretical Education.—Almost any technical college of prominence offers a sufficient array of subjects for the youth training as a highway engineer, but some little guidance as to suitable subjects may not be out of place. The author, therefore, suggests the following subjects as providing a suitable course of study for those who are to undertake later on the duties of a highway engineer.

The course might include:

Geometrical Drawing.
Plane and Solid Geometry.
Building Construction.
Machine Construction.
Mathematics, including Trigonometry.
Theory of Structures.
Applied Mechanics, including Graphic Statics.
Strength of Materials.
Engineering Chemistry.
Geology.
Geodesy.
Sanitary Science.

About half of these subjects may be taken at a good average technical school, and the student should make the most of his time by gaining a thorough grounding in them By this means he will be better prepared to take up the more specialized subjects which he can study later on by means of good correspondence tuition. If he can obtain tuition in all of these subjects above stated at a technical college, he should by no means miss the opportunity. It is important that he should not take up too many subjects at one time, but spread them over a few years. The value of the re-writing carefully and regularly of his notes of lectures is too apparent to need emphasizing. Lecture notes properly recorded and set down in the student's own words can be referred to in after years, and are thus of the greatest use, and often make it unnecessary to wade through bulky text books for information required. An essential preliminary to any course of technical instruction is a good sound education, and it is assumed that, before taking up his training, an apprentice or pupil to a highway engineer has reached a standard of general education necessary and fitting for his professional career. This standard may be taken as that of the Scottish Education Department's higher leaving certificate or the preliminary examination of a university.

Examination Tests and the Preparation for Them.—There are many capable engineers who regard a professional examination as an unnecessary thing which affords no real test of a candidate's ability. There was something to be said for this point of view when examinations were almost entirely of a theoretical or academic nature, but within recent years there has been a considerable infusion of really practical detail into some examinations, and this has greatly enhanced their value. Up to seven or eight years ago no exclusive examination existed which formed a test of a highway engineer's training and experience. The institution, recognizing the need for such a thing, introduced the examination for the certificate in county and highway engineering. The requirements of this examination are, perhaps, struck more from the English than from the Scottish standpoint, but there is no doubt whatever that it is at once the most suitable and at the same time the most specialized test in this country so far as road engineers are concerned. The author would, therefore suggest that more prominence be given to this examination, and that every inducement should be extended to pupils and assistants who are anxious to secure reliable evidence of this technical and practical attainments in highway engineering. To those who desire a good all-round test in subjects pertaining to general engineering and administration, there is no better diploma to gain than the testamur of the institution. The value of this diploma is evidenced by the large number of candidates who sit for the relative examination each year and by the number of local authorities who, in making official appointments, either insist upon the candidates being holders of the testamur or indicate that the possession of it will be a recommendation. There are, unfortunately, few candidates from Scotland at these examinations, and this is perhaps due in a measure to their being held almost invariably in London. Were they held at different centers, including, for example, Glasgow and Edinburgh, they would tend to become more popular in the North. The difficulties of organizing these examinations outside the metropolis are, no doubt, considerable, but they ought not to be insuperable.

The question of tuition naturally asserts itself, and herein lies a difficulty so far as most road surveyors' pupils and assistants are concerned. In most cases the highways office is so situated as to be out of reach of a technical college or other institution affording a suitable technical education, and candidates are obliged to take up what is sometimes a rather doubtful method—namely, correspondence tuition. Now, there are several sound firms who take up this method of coaching for examinations, but before a student engages in such a course he should satisfy himself that the tuition offered is thoroughly up to date, that it covers amply the requirements of the examination, and that the tutors are persons of proved ability.

This form of tuition, convenient though it is, is largely dependent upon the student and how he tackles his work of preparation. In order that this or any other method be rendered more successful, the author is of opinion that it should be amplified by methods which he suggests in the following section.

Further Suggestions.—A system which has been adopted with much success of late in other spheres is that of the summer school. The method consists of holding at one or more suitable places during the summer months a series of lectures and demonstrations by prominent persons. These gatherings generally extend from a week-end to a whole week and sometimes longer, and provide the means of bringing students and others into touch with persons who are recognized authorities in their particular branch of learning. Accommodation is generally provided at a moderate rate, while other facilities are also kept in mind. The author does not think that it would be a difficult matter to introduce such a method which would be of so much benefit, particularly to the younger members of the profession. The success of the scheme would, however, be dependent upon the amount of interest taken by the profession as a whole.

The proposal has been put forward of creating a Chair of Highway Engineering in one or more of our universities. It is a thoroughly good one, but is, perhaps, not possible of general adoption at the present time. There is another method, however, which ought to be developed more than it is—namely, the formation in our universities of honorary professorships. So far as the author is aware, this has only been adopted with regard to harbor engineering and railway engineering. It involves the appointment of a practizing engineer who is an expert in his particular branch of engineering and the method therefore provides that practical touch which is so essential in the case of a university engineering education. There is no reason whatever why the arrangement should not be extended to include highway engineering. By it students would be brought into frequent touch with professional men who are day after day carrying out in practice the best methods of road maintenance and all matters connected therewith.

As another aid towards increasing the efficiency of the profession, the Clearing House idea might be considered. There is such a variety of experience gone through in all parts of the country appertaining to road matters that it seems strange that no definite attempt has so far been made to collate the information obtained, thereafter making it available for the use of all members of the profession. Certain associations have done much good work in this direction, but their efforts have been somewhat restricted owing to their being voluntarily supported. The application of the Clearing House idea to road matters is deserving of the most earnest consideration. Perhaps this could best be realized by the establishment under the Ministry of Transport Roads Department of a bureau of road information maintained out of taxation. Information gathered from all parts of the country could be critically examined by a staff of skilled engineers, tabulated and made up into useful reports dealing with all matters connected with roadmaking and maintenance. The possibilities of such a method are obvious, and the diffusion of the information obtained could not fail to be of immense practical value to all who are engaged in making and maintaining the country's highways.

Practical Training.—Important though the office work of a highways department is, it cannot be regarded as of equal importance to the outdoor work. The keeping of records, the preparation of plans and estimates and other office work, although affording valuable experience, are of little consequence in themselves, and must necessarily be supplemented by a systematic outdoor experience.

What is of outstanding importance to a highway engineer is the need for him to become thoroughly familiar with the road system of his district, the subsoil, the nature and sources of the available road stones, and the most suitable methods of coping with road wastage. In this connection stress may be laid upon the working of quarries.

In some districts the supply of suitable road material is a serious question, and much attention must be paid to the utilization of what local materials exist. The opening up of quarries and their development along proper lines are matters of paramount importance. Again, where an extensive plant is utilized, the greatest care has to be observed with regard to its arrangement so as to permit of economical and expeditious working. Much can be learned by a young engineer by frequent visits to the quarries. He should make himself familiar with every detail connected with the production of metal by studying the methods of quarrying, drilling and blasting, and the mechanical principles of stone-breaking plant. The same might be said of all other machinery employed in connection with highway work, such as steam and petrol rollers, tractors, tar-macadam mixing plant, and so on. He may not possess the advantages of a training in mechanical engineering, but he can at least make use of every opportunity for studying all kinds of road plant sufficiently well to be able to discuss its arrangement, use and repair with the men in charge in an intelligent manner.

His attention should also be directed to the organization of workmen and the execution of work generally, in such a way as to produce the maximum of efficiency with the minimum of plant and labor.

In the matter of surveying it should be borne in mind that a mere book knewledge of the subject is quite inadequate. What is essential is frequent practice in the field, and perhaps the best form of this is the setting out or location of works. Generally speaking, it may be said that one who is able to set out accurately a job of fair size can execute a survey without difficulty. Moreover, it is highly desirable that the records of a survey be entered with sufficient care and clarity, so that no difficulty in plotting them may be experienced even by another member of the staff than the actual surveyor. Convenient although ordnance maps are, they should not be used when a larger scale plan is really necessary.

General Requirements.—To tabulate the main points to be aimed at in a highway engineer's training, the author puts forward the following:

(a) A sound, practical knowledge of surveying and levelling, the principles and care of instruments and the ability to make and check observations, and the accurate plotting of same.

(b) Ample practice in draughtsmanship and the proper use and care of drawing and computing instruments.

(c) A good, all-round knowledge of the various materials used in road making and maintenance, the tests applied to same and the methods of using.

(d) A sound knowledge of the different kinds of plant used in connection with the production and transport of materials and the making and maintaining of roads. Ability to know exactly the type of plant to employ economically upon a particular class of work.

(e) A thorough knowledge of the methods of costing and general office routine.

(f) Ability to take out quantities, draw up specifications, prepare estimates of probable cost, as well as the making of inspections and the writing of reports.

(g) A satisfactory knowledge of the designing of bridges, culverts, retaining walls, etc., and the calculations involved therein.

(h) A complete grounding in the legal aspects of the profession—that is, a knowledge of the various Acts of Parliament and Orders applicable to roads and transports, in addition to the court decisions on important highway cases.

(i) Ample practice in the detailing and organizing of labor and plant engaged upon all branches of highway work.

(j) Sufficient knowledge of architectural design to enable him to execute the plans appertaining to roadmen's cottages, central depot, and stores, etc.

(k) The making use of every opportunity of broadening his knowledge by occasional visits to works in progress outside his own area, and generally keeping in touch with all the latest and most up-to-date methods.

Such a paper as this would hardly be complete without some reference to the keeping of a diary. The author is afraid that the practice is not very general, yet the value of it is so great that it ought to be one of the first considerations of a surveyor. Notes and observations upon the conditions of roads, dispositions of plant, weather, quarries, labor, etc., set down at the end of each day are bound to form a record of immense value, especially as an aid to the preparation of annual, quarterly and other reports.

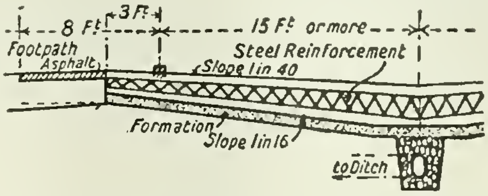
A mere theoretical training is not enough in itself, but it forms a groundwork or foundation upon which a sound, practical experience may be built. The haphazard and incomplete methods of training which have in the past pertained to such a large extent will not do. The profession of a highway engineer is now of such vital importance that some definite standard must be adopted. The author has therefore in these notes outlined what he believes to be the proper lines along which this standard may be followed and attained. In many respects the present is but a transition stage in highway engineering. The country's ways of communication, much neglected during the late war, are now emerging from the conditions which contribute to their wastage, and are admittedly showing gradual improvement. Among the factors which will in the future contribute to the production and maintenance of a thoroughly up-to-date road service serving adequately the needs of the people, none is of greater importance than a well-trained and efficient highway engineer.

Traffic on the Verdun Road.—In the course of his description of the heroic defence of Verdun in his speech in London General Petain, the commanding officer, stated that failing a railway capable of supplying the army, they had to make full use of road transport. But the only main road available was from the very beginning on the point of complete collapse under the strain of the very heavy traffic, combined with the damage caused by frost and thaw. It required for its upkeep an army of no fewer than 8,000 workmen, who tended it night and day, and thus enabled it to carry a traffic of 6,000 trucks every 24 hours.—The Surveyor, London.

Concave Concrete Pavement

From The Times Engineering Supplement, London.

A leading feature of a system of concrete road construction proposed by Mr. S. H. Walker, of the Walker-Weston Co., 7 Wormwood street, E. C. 2, London, England, is to make the under surface of the concrete slab, and also the surface of the road, slope down from the sides to the center, instead of cambering it in the usual way whereby the center is higher than the sides. He argues that if the slope is downwards from the sides to the center the concrete when it expands sideways under the influence of heat or moisture will have to do so uphill against the action of gravity, and when it contracts it will, so to speak, pull itself together towards the center of the road. For a country arterial road having a roadway 30 ft. wide or more he would make the formation slope downwards 1 in 16 from the sides to a central level portion 6 ft. wide.



Half Section of Concave Concrete Pavement.

The formation would consist of a porous layer of ashes or clean gravel well rolled with a 10-ton roller and left with a perfectly smooth surface upon which the concrete slab would be able to slide freely, special care being taken to see that the bearing capacity is equal throughout. The concrete slab would be perhaps 12 in. thick at the middle, but thinner at the sides. The concrete at the bottom would be composed of 1 part of cement to 6 parts of Thames ballast, or like mixture, and the surface layer, 2 in. thick, would consist of 1 part of cement to 1¼ of sand and three of 2½-in. broken granite chips, and would be laid just before the bottom concrete had set. The slab would be reinforced by a double layer reinforcement weighing 12 lb. per square yard, and consisting of top and bottom layers of steel connected together to form a mattress by diagonal tension shear members. The surface would slope uniformly down to the center at 1 in 30 to 1 in 50. Such a slope, while ample for a clean surfaced road like concrete, would hardly be noticeable; but as the part of the road nearest the footpath would be the driest and the slope and character of the surface would be uniform, the slower horse traffic would naturally tend to keep close to the curb, thus remedying one of the causes of traffic congestion. The banking of the road would also be correct for fast traffic overtaking slow. Mr. Walker suggests that the concrete roadway might with advantage be carried well past the curb to form part of the footpath; and if granite or concrete spur stones were used instead of a continuous curb, machine sweeping of the road would be facilitated, and a cyclist would be able to ride on the footpath in an emergency in order to avoid a fast motor car or other dangerous traffic.

Coal Shortage Drives Austria to Electrification

The Austrian Government, despite all difficulties, is actively engaged on the electrification of her principal railways necessitated by the scarcity of coal. Work is proceeding on the Alberg line, for which two power stations will be utilized.

One of these is the Ruetz power station, which is already in use for the part of the line known as the Mittenwaldbahn (from Innsbrück to Reutte via Garmitz and Partenkirchen). It is on the Tyrolese side, and will have to be enlarged and extended. The other is the Spullersee power station, which is now being constructed, on the Vorarlberg side of the line. The Spullersee power station is a high pressure station, with a water storage lake, the Spuller Lake, from which it takes its name. The fall of water utilized is about 875 yards. The Spullersee power station will be in the Kloster Valley, and when completed will have six sets of engines of 8,000 h. p. each, altogether 48,000 h. p., to produce monophase, alternating current of 15,000-volt, at 16⅔ periods. At present only three engines are erected. The power stations will be connected together by 55,000-volt overhead lines.—The Railway Engineer, London.

Measurement and Records of Suspended Impurities of the Air

From The Engineer, London.

A paper upon the "Suspended Impurity in the Air," by Dr. J. C. Owens, was contributed by Sir Napier Shaw to the Royal Society in November last year, and is reprinted in Vol. 101 of that society's "Transactions." This paper contains a description of another instrument which has been devised by Dr. Owens for the measurement of suspended atmospheric pollution, and since the results obtained in preliminary observations with this new dust recorder are of far-reaching significance and importance, a description of it is appended to this article.

The new instrument is known as the jet apparatus for dust examination, and depends for its action upon the fact that when air which contains dust and a sufficient amount of water in the form of vapor has its pressure suddenly reduced, there is a fall of temperature and a condensation of moisture upon the dust. If the dust particles thus enveloped in moisture be brought into contact with a glass surface and the moisture be then evaporated, the dust will adhere and can be examined microscopically. In the instrument this result is brought about by causing a very fine ribbon-shaped jet of air to strike a microscope cover glass, placed about 1 mm. from the opening forming the jet. The air before entering the jet passes through a damping chamber, and the velocity in the jet is such that the fall of pressure results in bringing about a condensation of moisture on the dust at the moment of striking the cover glass. The air is then deflected, and as the velocity falls off the pressure and temperature rise, the water is evaporated, and the dust is left behind as a deposit on the glass.

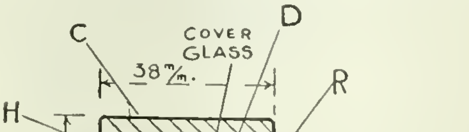


FIG. 1.
SECTION

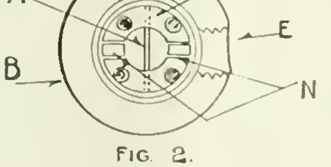


FIG. 2.
PLAN WITH PLUG "C" REMOVED

The Owens Jet Apparatus for Dust Examinations.

Figs. 1 and 2 show that the apparatus consists of a brass sleeve B, open at the top and bottom, and screwed internally for the reception of a plug K. The latter is perforated by a central hole, for admitting the air to a narrow slot formed diametrcially across the hole by means of two semi-circular metallic plates, held in position by a ring R, attached to the plug K. The upper surface of this ring is recessed to form a bed for a microscope cover glass, and a central cell, 1 cm. in diameter and 1 mm. deep, is thus formed under this cover glass. In the floor of this cell is the narrow slot for admitting air.

Into the upper opening of the sleeve B screws a solid plug C, on the inner face of which is fixed a three-claw spring, by which the cover glass is held gently down upon its bed when the plug is screwed home. The washer H makes an air-tight joint between the plug C and the sleeve B. Inside the sleeve B and surrounding the cover glass is an annular recess which communicates with a connection E for attachment to a 50 cc. air pump. Channels N are formed on the upper surface of the ring R under the cover glass—shown in Fig. 2—so that when the air is drawn from the space between the plugs C and K by the air pump, a jet of air enters the slot A, impinges upon the cover glass and escapes to the annular space in B, and so to the pump E.

A damping chamber T, which is detachable from the plug K by unscrewing, is provided. This chamber is lined with blotting paper, which is wetted before the instrument is used.

To take a record the pump is fixed to the connection E. and before the plug C is removed three or four strokes of the pump are made to fill the damping chamber with air. The plug C is now removed, and a carefully cleaned cover glass is placed in position upon the ring R, after which the plug C is replaced rapidly and screwed home. The pump is then operated smartly so as to draw one or more volumes of air through the jet, allowing an interval of about one-quarter of a minute between each pump stroke, to permit the air to absorb moisture. The plug C is finally removed, and the cover glass is dropped out on to the hand and mounted on a microscope slip.

The record consists of a linear deposit of dust, and a count of the number of particles in this way may be made by the aid of the eyepiece micrometer, a strip being counted completely across the record at one or two places, and an average taken. This figure multiplied into a factor, depending upon the magnification used, will give the number of dust particles on the record.

Practical Applications of the Method.—The practical applications of this microscopical method of determining the amount and character of the suspended impurity of the air are many and varied, and only one can be named here. The chief source of suspended atmospheric impurity in this country is the burning of smoky fuel. The seasonal variation is very well marked, the quantity of impurity falling off to a minimum in the summer and rising to a maximum in the winter, when the domestic fires are in full operation. There is a similar relation in the hourly variation, the only period comparatively free from smoke pollution being the small hours of the morning when fires are out. The distance to which smoke impurities travel from their source is not known; but Dr. Owens and other observers have noticed that when the meteorological conditions are suitable, it was usual to find a bluish haze overlying the whole country. By aid of the filter described previously, this haze was found to be composed of solid particles, which gave a distinct discolored record on the white filter paper. It is a matter of conjecture where these particles have come from, but Dr. Owens hazards the statement that they are often derived from the smoke of continental fires. From observations made by him on the East Coast last August, in fact, it appears highly probable that the great industrial activity of Germany, when the wind conditions are favorable, is responsible for a fair proportion of the suspended impurity in the air over this country.

Roads and Streets Issue

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(b) Quarries and Pits (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works (c) Sewers and Sanitation
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(a) Steam Railway Construction and Maintenance (b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

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(a) Buildings (d) Miscellaneous Structures
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Developments in Highway Illumination

Development in the science of highway illumination during the past year or two has been sufficient to warrant the expectation of many well-lighted rural highways in the near future. We think that there should be little complaint at the rate of progress in this field, for the satisfactory illumination of city streets and public places is of less than a generation standing, and is, in fact, still far from complete. Country roads, having always been dark; the average person has not even stopped to consider that they might be otherwise.

The reasons for the dark roads of the past are obvious, but the changes in character and the tremendous development in volume of highway traffic has brought an economic need for illumination which electrical science was waiting practically ready to fulfill. The developments on which progress has recently waited were optical rather than electrical in character, and would no doubt have come earlier had the imagination of the highway-using public been sufficient to demand them. While in the light of present knowledge we can look forward to the illumination of but a very small percentage of our two-and-one-half million miles of public roads, the heavy traffic thoroughfares radiating from and connecting important centers of population are now in the way of being lighted to the real benefit of night travelers.

Our issue of Aug. 2 contained a brief illustrated article describing the system of illumination which is to be installed on the "Ideal Section" of the Lincoln Highway in Lake County, Indiana. Especially is it to be noted that the light should be distributed as evenly as possible along the length of the road. What driver has not experienced the maddening sensation of passing rapidly through alternate bright areas adjacent to lamps and patches of inky blackness between?

We have no notion that the illumination of the Ideal Highway represents the final development in this field, but it should lead to improvement along the lines already begun and should stimulate invention in new fields, until in the end the lighting of our roads is on a par with other institutions of this age.

When in addition to such advancements, drivers are forced to a proper regulation of their own lights, both the pleasure and safety of night-driving will be vastly increased.

What Is the Life of Corrugated Culvert Pipe?

Recently we wrote to 1,000 subscribers who are highway engineers, asking them whether they used corrugated pipe culverts. They were not asked to express any opinions as to this type of culvert, our object being merely to determine, in a general way, the extent of use of corrugated culverts by readers of this journal.

Thirteen of the 48 State Highway Engineers were among those interrogated. Eleven replied that they use corrugated culverts, and two report that they do not. One reply reads: "Will advise that this department uses metal culverts in all of its small drainage structures." Another reply reads: "Would say that we do use on our highway work a considerable amount of corrugated culvert pipe, and shall continue to do so." Still another wrote: "We have used corrugated culverts for the last thirteen years on our State Highway and State Aid Roads."

The two State Highway Engineers who do not specify corrugated culverts for "permanent work" cited a recent ruling of the Bureau of Public Roads as a basis for this stand. This raises a question as to what constitutes "permanency" in road work. Highway permanency is, of course, a relative term, since no pavement is everlasting. Hence if a culvert will last as long as the pavement over it, it may be called "permanent."

It is the claim of the manufacturers of certain class of iron culverts that their life is as great as that of any pavement. We understand that one corrugated culvert 27 years old is still in good condition. The editor recently inspected a thin sheet-steel water pipe that has been in service 33 years under heavy pressure, and that seems good for 10 or more years.

In the Proceedings of the American Water Works Association, 1894, page 181, some data are given as to the corrosion of iron and steel. An instance is cited of a wrought iron pipe ⅛ inch thick, laid at the Merrimack Co.'s mills, Lowell, Mass., in 1845. A piece of this pipe was cut out in 1887, when it was 43 years old, and it seemed evident that the pipe was good for another 40 years. We have recently tried to ascertain whether that pipe is still in use, but have been, as yet, unable to learn.

There are many facts like this that point to a life of 50 years or more for pure wrought iron pipe under favorable conditions, and as engineers begin to learn of these facts they are changing their opinions as to the "permanency" of thin wrought iron that is sufficiently pure.

It is obvious, we think, that the average culvert pipe is less apt to rust out than the average water pipe; so that if a long life can be established for wrought iron water pipe, an even longer life can be inferred for culvert pipe of the same material.

Engineers who have read little or none of the literature on rusting of iron and steel, seldom know that rusting is the effect of an electrolytic action, and such action is impossible where iron is perfectly pure and where no excessive internal stress exists at any point. Lacking this knowledge they frequently condemn all iron pipe because they know of some instances of short-lived iron pipe.

Answering the query in the title of this article we would say that the life of corrugated culvert pipe depends mainly upon the chemical character of the metal; and that if the most carefully prepared iron is used, the life will probably exceed any pavement under ordinary conditions.

A Method of Mechanical Analysis of Sub-Grade Soil

A method for the determination of the amount of sand, silt, clay and ultra-clay* in subgrade soils was submitted by the American Society for Testing Materials' Committee on Roads and Paving Materials at the recent annual meeting of the society. The method, which was submitted as tentative, is as follows:

The sample as received shall be dried in an oven at a temperature not to exceed 100° C. (212° F.) and shall then be broken up in a mortar by means of a rubber-covered pestle, care being taken not to break any fragments of rock or sand. The sample shall then be passed through a ¼-in. screen and the material passing this screen further pulverized by rolling out in a thin layer on a rubber pad, using a rubber-covered roller.

The apparatus shall consist of a wide-mouthed cylindrical glass jar of at least 10 liters capacity; a soil centrifuge with a four or eight-tube head of such diameter that a speed of 1,500 r.p.m. will exert a centrifugal force approximately 500 times the force of gravity; four centrifuge tubes of 100-cc. capacity; and a chemical balance sensitive to 0.001 g.

A 25-g. sample of soil passing the 10-mesh sieve and prepared as specified in Section 2 shall be placed in a beaker with approximately 500 cc. of distilled water, gradually brought to the boiling point and shall then be allowed to stand for about 24 hours. Care should be taken not to boil for more than two or three minutes, as continued boiling tends to cause coagulation. After standing for approximately 24 hours, the material in the beaker shall be thoroughly brushed and dispersed with a stiff brush for two or three minutes, and then allowed to stand for eight minutes. The supernatant liquid shall then be decanted into a vessel having a capacity of about 10 liters. About 500 cc. of ammoniated water (concentration 1:500) shall be added to the material remaining in the beaker and the brushing repeated as before. After standing for eight minutes, the supernatant liquid shall be decanted into a large vessel. This process shall be repeated until the supernatant liquid becomes clear after eight minutes sedimentation. The sand and silt will have become separated from the clay and ultra-clay, which are contained in the large vessel. The material in the beaker shall be transferred to an evaporating dish, dried in an oven to constant weight at a temperature of 100° C. (212° F.), cooled, and a mechanical analysis made, using 20, 50, 100 and 200-mesh sieves. The material retained on each sieve shall be recorded as a percentage of the original 25-g. sample, and that which passes the 200-mesh sieve shall be recorded as the percentage of silt in the original sample.

The volume of the liquid in the large vessel shall be brought up to at least 10 liters by the addition of ammoniated water, and the vessel thoroughly shaken until all material is in suspension. Seventy cubic centimeters shall then be siphoned from this vessel at a depth of about one-half the total depth of the liquid into each of four centrifuge tubes. The tubes shall then be mounted in the centrifuge and run for 30 minutes at a speed which, for the diameter of the head used, will exert a centrifugal force approximately 500 times the force of gravity. The material which has been thrown out of the liquid by centrifuging shall be classified as clay and that which remains in suspension as ultra-clay. The solution containing the ultra-clay shall be decanted, evaporated to dryness, and the weight of the ultra-clay determined. The clay remaining in the tube shall also be dried and weighed.

The weight of ultra-clay is determined from the liquid in four tubes, or 280 cc.; consequently this weight must be multiplied by the factor obtained by dividing the total volume used by 280 cc. in order to obtain the total amount of ultra-clay in the original 25-g. sample. The weight of clay is determined from the clay in one tube, of 70 cc.; therefore the total volume divided by 70 cc. gives the factor by which this weight should be multiplied to give the total clay in the original 25-g sample. The total weights of clay and ultra-clay thus obtained shall be converted into percentage of the original 25-g. sample.

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*The determination of the percentage of ultra-clay by this method will include any water-soluble material present which may be determined separately if desirable.

Open Top Cars Released for Construction Industry

As a result of the petition submitted by the Associated General Contractors of America, requesting a revision of the coal priority orders, and the subsequent hearing granted to the Association by the Interstate Commerce Commission, Service Order No. 23 has been amended to permit the use of open-top cars for the movement of commodities other than coal.

The new amendment to this service order will release approximately 34,000 additional open-top cars, which will avoid the practical shut-down of the majority of construction projects that confronted the construction industry. The amendment will take effect at midnight, Sept. 3, 1922.

Promptly upon the issuance by the Commission of service orders giving demands for open-top cars for fuel for any purpose priority over requests for opn-top cars for other purposes, the Associated General Contractors submitted their petition showing how the continuance of these orders meant such a shut-down.

Upon consideration of this petition the Commission heard the case for the construction industry on Aug. 25. Following this hearing, and on the request of the Commission, further facts regarding the magnitude of the industry in terms of contracts, money and men, and the relationship between construction of housing facilities and for all commercial purpuses, were furnished.

This modification of orders is of the greatest importance to every one interested in construction and especially to all contractors, who now can be reasonably certain of the delivery of necessary materials for their various jobs.

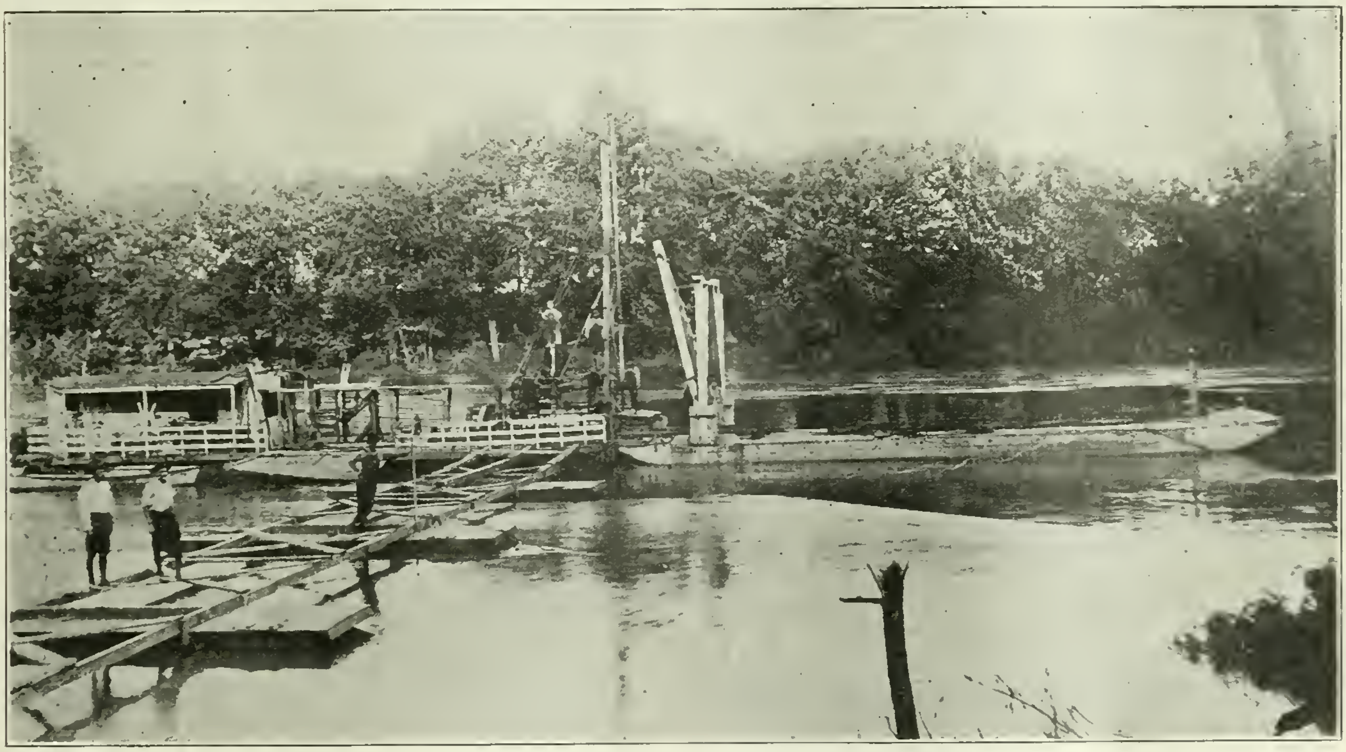
The Cash Value of Roads.—The congressional commission which has been investigating agricultural problems has issued some illuminating statistics showing the cash value of good roads to the farmer. From farm to shipping point, in 1918, the cost of wagon hauling was approximately 30 ct. per ton mile for wheat, 33 ct. for corn, and 48 ct. for cotton. Over the same route now, but on hard surfaced roads and by means of motor trucks, the cost is 15 ct. per ton mile for wheat and corn, and 18 ct. for cotton.

Street Sanitation Conference Set for New Date.—The International Association of Street Sanitation Officials will meet in conference at Hotel La Salle, Chicago, on Oct. 9 and 10, instead of earlier in the month, as originally planned. The secretary's office is 10 South La Salle St., Chicago.

Rock Borings for Highway Bridge Piers Made with Well Drilling Machine

By N. H. MERIWETHER,
County Engineer, Clarksville, Tenn.

The Cumberland River bridge in Federal Aid Project No. 16 is to be built approximately 2 miles above Clarksville, Tenn., at Gaissers Bluff. The river at this point is approximately 580 ft. wide, and at pool stage some 19 ft. deep, the bottom being gravel and practically level between banks. The bridge to be constructed consists of two 180 ft. spans and one 280 ft. span, the longer span crossing the main channel. The long span is to be placed on two concrete pillars located some 130 ft. and 150 ft. from the banks of the river. As these two piers are to carry to considerable weight, some doubt was felt in proceeding with their construction until the rock strata had been drilled into to ascertain if any caverns existed. I was ordered to drill into the rock strata for approximately 30 ft., making two soundings at each pier, 20 ft. right and left of the center line respectively.



Well Drilling Rig Mounted on Ferry Boat Making Borings for Bridge Pier.

I at once proceeded to dig up data on soundings for bridge piers, and, much to my surprise, I found very meager information on soundings made in river channels where the currents were a factor to contend with, and practically no data on drilling into rock for cavern formations. In fact most of the soundings data covered the use of probing rods, dirt augers and sand pumps, all of which equipment was good to sound rock but not to drill into the rock.

I next proceeded to make plans along my own ideas as to layout and equipment. I first secured a small well drilling machine, which I located in the country. It was a very old model of the St. Louis Cable Tool well drill, and had a string of 6 in. tools consisting of head, jars, stem and two bits, the entire string weighing 1,200 lb. Next I proceeded to get suitable barges to float this rig. The county operates three ferry boats, and as one of the ferry boats just filled the bill, I detoured the traffic to one of the other boats and took it to float this rig. This boat was 57x15 ft. decked, and had a tonnage capacity of 11 tons, also was operated by a 10-H. P. Fairbanks-Morse gas engine. I knew that one boat would not be rigid enough for the work so I proceeded to find a second barge and finally located exactly what I needed, a Government barge which was not in use at the time and which was equipped with snag pulling derrick, capstan and spuds. The spuds could not be used on account of the depth of the water. This barge was 57x15.

I mounted my well rig on the bow of the ferry boat on some 6x6 timbers 36 ft. long, and placed the Government barge in front of the ferry boat and let the 6x6 timbers extend on to the barge, thus distributing the weight over both the boats, and left a space between them of 8 in. through which to operate the drill.

As the current was swift and the river high, I realized it would be difficult to hold the boat steady enough to drill with anchors, and I wished to arrange the rig so that when once I started drilling I would not have the trouble of getting my holes crooked, and to accomplish this, I designed a pontoon line, to run from the bank, to the side of the boats which would hold them steady. The pontoon line consisted of four 5x20 ft. boats decked, spaced 27 ft. apart, and on them was laid two 4 in. x 6 in. timbers 8 ft. apart, with 4 in. x 6 in. cross braces and 2x8 X-bracing. The two 4x6 stringers were carefully spliced with butt joint splices and bolted with fish plates on both sides of splices. The two 4x6 stringers were butted against one side of the boat gunnels and extended to the bank, where they were pinned like a wagon bolster with a 1 in. bolt 14 in. long to two 6x6 timbers. These 6x6 timbers were placed one on each side of a tree with heavy cross timbers bolted to them, making a link hitch some 12 ft. long. This particular feature was to adjust the length of the pontoon line and to take care of the rise and fall of the river. A block and tackle was hitched to the cross-braces on the link and to the tree so that the link could be pushed out or pulled in at will. This link, which was connected with the pin to the cross-brace on the pontoon line, acted like a fifth wheel and permitted moving the barge up and down the river in a circular motion and also permitted drilling the two soundings at each pier without changing the pontoon line. We found it necessary to put two steadying lines from the end of the link hitched to trees on each side to hold it rigid.

I next pulled my barges to place in the river by the power from the ferry boat and ran out two lines to trees on the bank. These lines were approximately 400 ft. long and were made fast to the left hand cavel facing the bow; then I ran off one tail line making fast from the left hand cavel, carrying to convenient tree on the bank. This line was some 250 ft. in length. I at first used ¾ in. rope but found that the rope had too much give to it so changed for ¼ in. cable, which I found to be sufficiently strong.

Having previously laid out a base and angle line for sounding point, I placed two range poles 20 ft. to right of center line and ranged in, checking with transit on angle line. After locating on point all lines were pulled tight, thus bringing barges against end of pontoon line, which acted like the stiff leg of a derrick and held the entire rig rigid on location. During the entire drilling I had no trouble from the rig getting out of line from hole.

After getting located and all lines tight we proceeded to put the casing into place. We had one piece of 17 ft. casing and one piece of 18 ft. 6 in. and four pieces 5 ft. each, all 6¼ in. in diameter. The two long pieces were made up. The water was about 32 ft. deep, as the river was quite high. We raised the 36 ft. 6 in. section of casing with the well rig derrick and lowered the casing into place between the barges. Some difficulty was experienced on account of the current, but we lashed the top of casing to the derrick and pulled it to line and drove into gravel with sledge hammers to hold it in place. We then raised the string of tools and lowered them into the casing and put a driving shoe on the rope socket and proceeded to drive the casing through gravel to rock. We drove some 8 ft. and, as the casing was not driving very easy, started to drilling.

The drill was operated with power from the ferry boat engine and was geared to run 30 strokes per minute. We wished to run the drill very slow as we anticipated trouble in handling drill, and our experience justified every precaution. After churning up gravel with drill, we bailed out and continued drilling. We found that the gravel was very hard to drill up and the progress was slow. After drilling to bottom of casing we thought that we could continue drilling and the casing would follow the drill, but found that the drill was hung on the bottom of the casing and it almost pulled the casing out before it could be cleared. We then put on driving shoe and drove the casing until it stopped at about 14 ft., at which elevation we had previously made soundings with probing rods and established rock strata. Then the drilling was continued. The most difficult and the slowest progress was made just at the rock strata, as the gravel and sand would continue to push in and fill up casing. There also seemed to be a heavy water stream and we found that until the stroke of the drill got below bottom of the casing into rock that progress was slow. In fact we would drill some 20 to 30 hours and not penetrate more than 12 to 14 in.

On the first sounding, which I designated as "A," it being 20 ft. to the left of center line on Pier No. 2, we drilled 30 ft. into rock, taking samples from the cuttings every 3 to 5 ft. These samples were placed in Rayo lamp chimneys so that they showed the strata formations and notation of elevation of each sample was made on a sticker and placed on the outside of the chimney. We found the formation to be hard blue limestone in stratas from 3 to 5 ft. thick, and usually harder at the seams and especially hard at top of first strata. On the first sounding we averaged about 3 to 4 feet in 12-hour shifts. The slow average of penetration was due to drilling on water as the motion of the barges up and down with the rise and fall of the drill caused about 50 per cent of the strokes to hit short. We found that we could not drill with slack line as same or worse results were obtained. I wish to caution any prospective sounding driller not to rush the drill as you are sure to hang, and fishing tools in the river off of barges is not satisfactory.

After finishing the sounding we drew the casing, using the derrick on Government barge, and a 4-string block, and pulled fall line with capstan. It was a rather heavy pull, breaking the ⅜ in. chain which was used for a hitch, and almost sinking the two boats; but finally it gave way and we pulled it out with the well derrick.

The head lines were then loosened and the outfit floated 40 ft. down stream to Sounding "B" on Pier No. 2. Casing was dropped into place in the same manner as previously described, but (profiting by experience) was driven to rock before drilling was started. This sounding was the same as at "A," and about the same speed was made in drilling. After completion, casing was pulled and the entire rig moved across the river and located in same manner, but we found the current much swifter and considerable drift running. The head lines parted just as we thought every thing ready to set casing, and to keep from wrecking the pontoon line we were compelled to cut the barges loose. It was an exciting moment, and we had the pleasure of cutting ropes drawn to the breaking point. Of course a day had been spent in hard labor, and all to do over again. We pulled back up the river and put on additional ropes and snubbed over the cavel down to place. The current was running about 8 miles per hour and the ferry engine could not hold the barge against it. Just as the boats caught the current the snub on the cavel jumped off, as it had been roped wrong, and we had a race to get the rope end around the capstan and catch the boats.

After two days fight, we were at last in place and driving casing. We were in for trouble. We had driven down on a sunken log and there was nothing to do but drive through. We drove the casing through at last, but flattened it so the drill would not go through, so we then had to let the drill hammer it out. This took 15 hours drilling with jars loose, and we hung the drill and twisted the main drive shaft. It was necessary to have a new drive shaft made so work was stopped while this was being done. It took a day and a half to make and replace the broken shaft and once more our drill started to pounding. I was now running a night shift by the aid of two Nash Quad headlights mounted on each end of the boats.

The third hole was very much the same formation as that previously described, except that a strata of white clay and gravel lay just above the rock strata. On the last hole on Pier No. 3 we had the best luck. The river having fallen the current did not bother us and we had no trouble driving the casing to rock. We found the same rock formation down for 28 ft. and then we struck soft soap stone for 2 ft. We ran drill down for 32 ft. and the rock hardened up to blue lime.

Five weeks were spent in actual drilling and one week shut down, on account of high water.

Effect of Road Conditions on Motor Truck Operating Cost

In a paper presented last February at a reginal conference on highway engineering and highway transport at the Agricultural and Mechanical College of Texas, Mayor I. C. Moller of New York City, pointed out that the character of the road had a very material influence upon motor truck operating costs. He gave the following items which go to make up a complete operating cost of a truck:

	Per cent.
Gasoline	23.8
Driver	20.0
Tires	17.1
Amortization or depreciation	12.7
Maintenance and repair	6.7
Insurance	6.5
Garage	5.5
Running supplies	2.7
Interstate and state license	2.7
Lubricating oil	1.2
Washing and polishing	1.1
Total	100.0

He stated that of these items the following are affected by road conditions:

	Per cent.
Gasoline	23.8
Tires	17.0
Amortization or depreciation	12.7
Maintenance and repair	6.7
Washing and polishing	1.1
Total	61.3

Bulletins of Road Conditions.—The State Highway Department of Indiana is issuing weekly bulletins to newspapers of the state on the condition of the principal roads in the state road system. Several newspapers have asked for this information, so they may print it in their Saturday issues for the benefit of the many persons who customarily spend Sundays motoring over state highways. The bulletins, according to John D. Williams, director, will contain information as regards conditions of state roads, bridges, detours, et cetera. The bulletins will be supplied to all newspapers, and also to the leading hotels which also will be supplied with an Indiana map showing state roads.

Motor-Truck License Fees.—In the 48 states there are no less than 17 different bases or combinations by which motor truck license fees are fixed. For passenger cars the horse power basis (used by 27 states) is the most prevalent, while for motor trucks the commonest form is the rated carrying capacity of the truck (used in 25 states). The other bases are gross weight (vehicle and load), weight of the vehicle, cost, piston displacement, total tire width, flat rate per vehicle, and various combinations of the foregoing.

Snow Removal on Interurban Highways

The Need, Methods and Organization, Discussed in Paper Presented at Annual Conference on Highway Engineering of University of Michigan

By C. J. BENNETT,
State Highway Commissioner of Connecticut.

In certain sections of the country where manufactured products are the main articles of commerce, the motor truck for the transportation of freight, or the passenger car for the transportation of passengers, in order to fill its proper sphere must, of necessity, be operated during the entire year, or with only such minor delays or discontinuances as may be easily taken care of by a short cessation of business. If business were arranged with regard to climate, some of the problems of the highway engineer as regards snow removal would be materially simplified. In certain sections of the country 100 per cent motor transportation is demanded, and in these sections, at certain times, snow falls in varying quantities and the problem of the engineer in its removal becomes a matter of very serious import.

Justifiable Expenditure for Snow Removal.—Neglecting the argument that the removal of snow is of material benefit in the maintenance of the highway because the effect of removal on maintenance is slight, we must consider carefully the value of snow removal per se. No matter what we may say regarding highways or how much we may disregard traffic, one of the fundamental principles of highway engineering must be that the road is built for the purpose of carrying traffic.

Having established a system of transportation dependent partially upon the motor vehicle transportation, it would seem almost an axiom that every possible effort should be made to provide for the operation of this class of traffic at all times.

Previously, we have had little or no knowledge regarding the value of the road in actual units of cost. It has been easy heretofore, almost universally to provide other means of transportation when snow fell, but there are certain sections of the country, notably that from which the writer comes, where the use of motor vehicles cannot be discontinued without serious inconvenience to the public. May we not say that indications seem to prove that snow removal is necessary in those locations where motor vehicle transport has become a necessary factor in the commercial life of the community?

The added convenience to those who use the roads for passenger purposes for their own comfort or convenience, while not a commercial or economic factor, is certainly something to be taken into serious consideration. In other words, it may be justifiable, speaking in practical terms, to expend up to $300 per mile in order that the motor vehicle may get full use of the road instead of 50 to 60 per cent of the use. This statement is further supported by the fact that in almost every instance of proper highway financing, we find the motor vehicle paying through license fees a sufficient amount of money to demand a 100 per cent service from the roads, or a reduction in license fee in proportion to the time during which the use of the roads may be discontinued.

Principles of Snow Removal.—We, all of us, are more or less familiar with the haphazard methods of snow removal employed, excepting in certain instances, and are familiar with the failures of these haphazard methods in particular cases. There are places, here and there, where snow removal has attained an important place in the work of the department having in charge the maintenance of highways, but these departments are still in the minority, and the methods employed generally are insufficient and expensive.

Based on the previous discussion of the need for snow removal and giving due weight to the importance and magnitude of the work to be done, particularly in the snow belt regions, we must admit that the problem of snow removal, if worthy of serious consideration, should be given such study as to provide the proper method applicable to the location in which the work should be done.

Ideal methods of snow removal are, of course, impossible to define excepting in a general way. Certain principles should be laid down, in order that the work may be successful. We must provide for speed. The attack must be sudden and continuous until the work is finished. This means expense and a sacrifice of efficiency.

In general, the problem of snow removal varies between extremely wide limits. There are those sections where the fall is light in total, but where occasionally heavy snowfalls occur. In these sections, provision must be made for the complete removal of snow from interurban highways, for in these sections the use of sleighs is practically unknown.

From this class of locality to the other extreme is a long jump, the other extreme being the places where snow fall is heavy and continuous and vehicular traffic, excepting over very much restricted distances, is unnecessary of consideration. In these localities, when winter comes, the use of the motor vehicle must be dispensed with unless its use becomes so important as to provide for heavy and continuous operations in snow removal.

Snow Removal Organization.—As regards the organization for carrying on the work, this should be formed generally around the organization having in charge the maintenance of the highway system. In general, the men used in the summer time for maintenance purposes may be subject to call, and the regular salaried personnel be used for supervising the work. In cases of extreme stress and emergency, advantage can be taken of local organizations or of contractors having special sources of labor or equipment. The work should be organized so that the necessary equipment is available at convenient points ready to go to work within a short distance of the point of storage. The work should be started immediately upon the commencement of the snow fall of any magnitude. In many instances the snow will stop falling soon, and some of the work will be wasted, but the advantages in the cases of extreme snow falls of having the jump on the job will more than offset any loss due to work being done when unnecessary.

The organization should be reliable, well trained with a knowledge of the job and with sufficient confidence in itself to carry on the work if the ordinary methods of communication, such as the telegraph or telephone fail. Each man should know his job, be willing to take the responsibility of carrying on the work to completion and be subjected to little, if any, blame if he makes serious mistakes, if these mistakes are honestly made.

The skeleton organization should be such that it covers the entire territory to be treated. There should be sufficient equipment available to do the job within a reasonable time and to do the job under maximum conditions rather than under average conditions.

No matter how large an organization may be attained, it will never be large enough to attack the problem of snow removal simultaneously at all points so as to clear the snow from all roads at the same time. In general, the problem resolves itself to those sections of highway which are more important and upon which the traffic may rightfully expect to pass within a reasonable time after the snow fall. In cases of continuous snow fall, it may be that the secondary routes will have to be neglected and traffic concentrated on the main routes.

In getting ready for the snow, we should take into consideration the co-operation with the United States Weather Bureau; but it is well not to rely too fully upon these reports because in many instances we have had snow storms which were not foretold by the Weather Department, although in general the service is of great value, supplementing our own efforts, particularly in cases of extreme storms.

Equipment Should Be Readily Available.—A great amount of equipment should be available. This equipment should be in the very best condition, housed in convenient and warm places, particularly in the case of motor trucks, so that it may take the character almost of a fire department subject to call in emergency and ready for the call without fail. This organization should be ready at any time, day or night.

Apparatus for the removal of snow from interurban highways should possess the vital quality of speed of movement. Such apparatus should be strong, rugged in construction, kept in good condition, and should be operated by men skilled in its use.

Inasmuch as the motor vehicle demands attention in traffic and is available in large numbers for work, particularly in the winter time, there is probably no more valuable agent for snow removal on highways than the motor vehicle with supplementary equipment.

Motor trucks have added advantage of being available for other purposes in the other seasons of the year, and does not call for such a large investment in plant as would be necessary if machinery were purchased for snow removal alone.

The degree of snow removal depends upon the class of traffic to be accommodated. Where traffic is diverse in character, there will be a constant strife between horse-drawn vehicles and the motor interests as to whether the road shall be suitable for wheel traffic or for horses. In general, a traffic census will determine very quickly which is the more important of these two agencies to accommodate, and the degree of removal can be measured by the magnitude of use of one or the other class of traffic. The width of removal depends again upon the amount of traffic to be accommodated, but in general, on heavily traveled routes, at least, a sufficient width for two lines of vehicles should be cleared, and if possible, snow pushed back during earlier snow falls so that future snow may be more easily disposed of. In certain instances, snow paths may be provided on the side of the road to accommodate horse-drawn traffic which otherwise would be seriously discommoded.

Apparatus for snow removal has not been developed as fast as the motor vehicle itself. This statement, of course, is also true regarding the development of the highway systems. In general, the work of the highway engineer has, of necessity, lagged behind the needs of transportation, simply because the general public has not been alive to the value of this method of accommodating traffic. Consequently, we are faced in the removal of snow with the same problem that we are in the construction and maintenance of highways. We have not developed our methods sufficiently to provide for snow removal, nor have we designed and constructed apparatus of a character to properly do the job.

Apparatus for Snow Removal.—In general the methods employed have been haphazard, and advantage has been taken of the equipment available, but the time must come when special mechanical devices, capable of attaching to motor trucks, or even operated under their own power, must be designed for the purpose of snow removal. The use of animals for snow removal purposes should receive only a remark in passing that in certain sections of the country, the use of draft animals will always be of value in this work, but on interurban highways where the roads must be opened quickly for vehicular traffic, the use of animals is obsolete.

Modern snow removal methods naturally mean the use of mechanical apparatus operated by gasoline motors; in other words, the truck with appliances attached, before or behind, or with a high class of mechanism designed particularly for the purpose of removal of snow. A great deal of advance has been made in the design and construction of this class of apparatus. At the present time, probably the most successful mechanical device and the most universally used is the scraper blade attached in front of a motor truck and set at an agle, used for the purpose of pushing the snow from one side to the other. Such a truck can be operated with continuous shifts of men if kept in good mechanical condition, and do an enormous amount of work, working 24 hurs a day, even up to seven days a week.

Spare parts and repair facilities must be available, especially where the truck is used thus continuously. The number of these trucks to be used will, of course, depend upon the degree of snow fall and the amount of work to be done.

In general, the truck will probably clean a reasonable snow fall on 2 miles of road in 24 hours, but in certain instances, the truck will be stalled so that it will only do a very small portion of this work in the case of an extremely heavy or wet snow fall.

In our section of the country, the weight of the snow varies between very wide limits. The light snow weighing from 12 to 14 lb. per cubic foot will often begin followed immediately by a fall of snow from 22 to 24 lb. per cubic foot.

The apparatus for removal must be designed to handle the heavier snow, and yet must be operated carefully in the light snow to obviate breakages. The advantage of using the motor truck may be used for other purposes in the summer time. The disadvantage is that the use of the truck for snow removal has a serious effect on the efficiency and life of the truck itself, especially when used for other purposes at other times. It is the opinion of the speaker that if the truck is used for a combination of snow removal and ordinary maintenance work, it should be charged up with 33 per cent depreciation each year. In other words, the truck will be used up at the end of three years.

The use of this equipment is restricted, of course, to roads which have a reasonably hard surface and during snow falls which are not seriously drifted. The drifting, of course, may be prevented by promptness in execution during the snow falls or the proper installation of snow fences at danger points. Drifts may be removed or broken out by the use of tractors with plows in front or behind. In general, the placing of the plow before the truck provides better footing for the wheels, or traction device much better than if the scraper or plow were pulled.

As we get into the niceties of snow removal, we will, however, find a use for other apparatus, some of it of the ordinary type, and much of it especially designed.

In order to start a discussion on this matter, it is the firm opinion of the writer that no method of snow melting or snow compression will ever be successfully operated due to the tremendous amount of heat or power necessary to melt the snow and to the probable defects due to freezing or choking of the apparatus itself, so that this discussion will neglect absolutely devices of this character and will confine itself principally to the mechanical means of removing snow in practically the same manner that earth is moved, although the material is of less weight per unit.

Viewed as an earth removal proposition, the apparatus designed for the removal of earth would be applicable to snow, excepting that the quantities of snow to be moved would be extremely large, and the allowable cost per unit must be very low, so that the devices for snow removal must be designed to handle quickly large quantities at a time and distribute the material in waste places without particular regard to appearance. Consequently, the ordinary earth removal devices are inadequate because they are designed to carry heavy material, but modifications of these devices can be made to be accommodated to the handling of snow.

Modifications of the conveyor, loader, the steam shovel and the steam excavator can be made so that these can be applied to snow removal. Several types which indicate a study on the part of the manufacturers of equipment have been manufactured here and there realizing the magnitude of the snow removal problem.

We are familiar with the centrifugal plow which has been used in Canada. The difficulty with this machine is that it is only hauled by horses and is restricted to the speed at which horses can travel. It disposes of the snow by throwing it up in the air and deflecting it on the sides of the road; and in this respect, it is useful on interurban highways. The width of path cut is narrow, and the radius of operation limited. Possibly some modification of this machine using a motor vehicle instead of horses for the tractive agent may be devised.

Other snow removal machinery of special character is as follows:

The snow tank which collects large quantities of snow in a receptacle and loads it into trucks or carts. Such a machine is of great value in the city and may be applied to the removal of snow in country districts.

Then, we have a rotary broom similar to those operated by the trolley companies, which is operated by a special motor being set at an angle and being removed in the opposite direction to the wheels of the truck so as to throw snow forward and to the side. The expense of installing these machines is, so far, the only drawback to their operation which can be justified in certain instances where the desire or demand for snow removal is more insistent.

There are other devices which are on the market at the present time and which are subject to examination. The writer has attempted to get information together regarding all the apparatus manufactured for snow removal purposes, and has seen quite a few advertisements and catalogs, none of which, however, seem to be in a condition to admit of very much discussion.

There is, of course, the snow compressing machinery. There is a snow removal machine which consists of a continuous belt with cutting baffles operated at a high speed by independent motor. There are rotary plows and deflective plows of all kinds, but none of these have come to the point where they can be successfully used. These are simply mentioned for purposes of discussion.

Measures for Preventing Snow Drifts.—All our statements previously have been made looking toward the removal of snow. We must not close a discussion of this kind without making mention of the absolutely important need of taking measures for the prevention of snow drifts by the erection of snow fences or the removal of obstructions such as weeds, hedges, board fences or anything of temporary character which will tend to cause snow drifts within the traveled portion of the highway.

Like the problem of snow removal the installation of snow fences requires forethought. It should not be left until the snow falls. Snow fences should be up before there is any possibility of snow drifts, and should remain in place by arrangement with abutting property owners until the possibility of snow has ceased. Snow fences can easily and cheaply be designed. There is no necessity of going into detail regarding the type of snow fence to be constructed. The location of the fence, however, is a vitally important factor.

In conclusion, let it be said that snow removal is a very real problem with state highway department maintenance crews; that it will be a very real problem and increase in magnitude as long as we have motor vehicles; that the amount of money to be expended on snow removal will only be limited by the value of service to traffic; that the cost of snow removal will vary from $50 to $250 per mile, and in cases of extreme snow fall, the cost may run even higher. Much of the work is thrown away and must be done over again. The permanent results are practically nothing. The work is done for the purpose of providing facilities for the motor vehicle and should be included in the taxes on the motor vehicle.

From an experience lasting over a considerable number of years in the fighting of snow, the writer has reached the point where he is extremely disturbed when the snow begins to fall, because it costs money to remove and the money might just as well be thrown away for all the effect the greater share of the expenditure has on the condition of the roads in the future.

Hand Auger for Borings for Drainage Structure Foundations

A hand boring outfit which is easily handled, inexpensive and capable of going through hard gravel is described in the July Tennessee Highways.

A hand auger consisting of a piece of auto spring twisted and sharpened, forming the auger point, is driven into a 4-ft. section of 1-in. pipe and securely pinned. The pipe extension lengths should be of 4-ft. sections and threaded a sufficient length to enable butting the ends inside of the unions. A T-connection with two 4-in. lengths of pipe forms handle. This outfit, 25 ft. long, should cost about $5.00. In addition, two pipe wrenches are also necessary.

Hand Drilling Auger.

Starting with the handle attached to the auger section, the drill is twisted into the ground about 6 in., then withdrawn and cleaned. This operation is repeated and the extension sections are added as the hole is deepened. This also gives a sample of the material through which the hole is bored. Where the hole quickly fills up again with soft clay or quicksand the drill may be twisted to any depth and removed with a lever or auto jack and chain. Two holes, each 20 ft. deep, have been drilled through silt and clay in one hour. Six holes, about 8 ft. deep. each, have been drilled through compact clay and gravel in about two hours. It took two men over an hour to go through 3 ft. of clay gravel, 6 in. of gravel conglomerate (rock) and 2 ft. of soft clay to bed rock. Soundings far off the general elevation or slope of the bed rock may be considered as hitting boulders, and a check sounding should be made a short distance to miss these boulders.

Effect of Age on the Strength of Concrete

By DUFF A. ABRAMS,

Professor in Charge Structural Materials Research Laboratory, Lewis Institute, Chicago.

Figure 1 is reproduced from "A Study of the California Highway System," by the U. S. Bureau of Public Roads, 1920, page 114. Compression tests were made on 4½-in. concrete cores cut from the pavements. The strengths have been corrected for length of specimen as compared with diameter and weighted on the basis of the number of tests included in a given average. The report contains the following comments on these tests:

> "The strength of the concrete is very nearly constant for all pavement classes, and, with the exception of Class A, the average for 1:2:4 concrete for the various classes is higher than for the 1:2½:5. The general average for both 1:2½:5 and 1:2:4 concrete decreases with age with a single exception of 1:2:4 concrete at 4 years and 1:2½:5 concrete at 5 years. In the case of 1:2:4 concrete only 6 specimens were tested at the age of 4 years, which may account for the comparatively high results. In general, there seems a slight tendency for the concrete to decrease in strength with age. This general tendency follows also within the various pavement classes, although there are several exceptions."

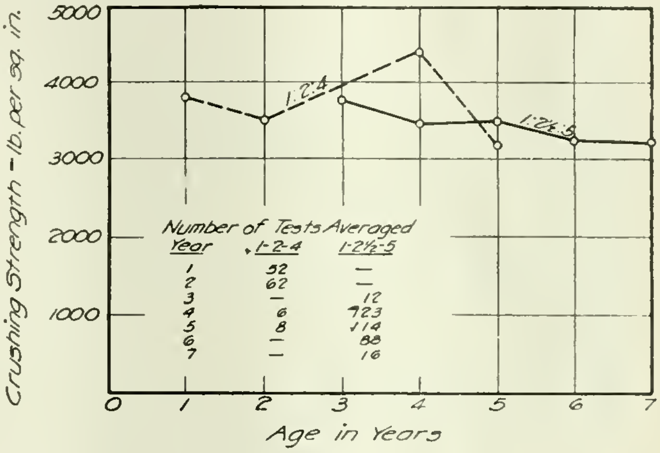


Fig. 1.—Diagram from "Study of California Highway System," by the U. S. Bureau of Public Roads, 1920—Page 114.

The same diagram appeared in "Public Roads" for April, 1921, in an abstract of the above-mentioned report, with the following comments:

> "(b) That since the average corrected testing strength of concrete cores is above 3,000 lb. to the square inch the concrete itself is not generally defective in strength nor does it show any wear by traffic.
>
> "(c) The average class condition of all concrete pavement indicates a slow progressive deterioration with the age of the pavement, and indicates also that the type built tends to reach its approximate stage of classification comparatively soon and thereafter to change more slowly.
>
> "(d) The diagram showing average strength as determined by cores tested from concrete laid during the various years indicates that there may be a slow progressive deterioration of the concrete itself, or 'fatigue' in a thin slab subject to excessive flexure."

It seems to the writer that the authors of the above-mentioned reports have misinterpreted this diagram when they state that these tests show "a slight tendency for the concrete to decrease in strength with age" and "that there may be a slow progressive deterioration of the concrete itself, or 'fatigue' in a thin slab subject to excessive flexure."

The writer can find no evidence either in the reports of the Bureau of Public Roads or elsewhere to indicate that the compressive strength of this concrete was reduced by "fatigue in a thin slab, due to excessive flexure." The first evidence of excessive flexure would be a tension crack in the concrete. It seems extremely unlikely that enough of these cores contained such cracks, even if in insipient form, to cause a material reduction in compressive strength, especially when we consider that the cores were loaded at right angles to the flexural stresses.

The writer places an entirely different interpretation on the tests represented in Fig. 1. Instead of showing a progressive deterioration of the concrete, it shows that there has been a progressive improvement in the quality of the concrete during the period covered by the work of the California Highway Department—sufficient improvement in fact to more than counteract the advantages of age on part of the older concrete pavements. Although all the work was done under the same specification, it is probable that increased experience on the part of contractors, more careful preparation and proportioning of materials, better inspection, and other factors of this kind are responsible for the marked improvement in quality of the concrete.

The notion that the strength of concrete deteriorates with age is based on the results of tension tests of mortar briquets. In a paper on the "Effect of Age on the Strength of Concrete" published in the Proceedings American Society for Testing Materials, 1918, Part II, the writer showed that briquet tests of mortars gave entirely erroneous results, due to the shape of the specimen in which (as pointed out by Johnson in 1898 and by Coker in 1912) the stress across the section is far from uniform. In other words, the falling off in strength of mortar briquets is due to the form of specimen and does not reflect the true properties of concrete. Tension tests of briquets practically always show this result both for water or air storage. On the other hand, concrete which is in contact with moisture continues to increase in strength indefinitely. Tests were cited in the above-mentioned report up to 9 years. (See "Concrete-Steel Construction" by Morsch.) Under these conditions the strength is a logarithmic function of the age; in other words, the strength is proportional to the logarithm of the age, expressed in weeks or months.

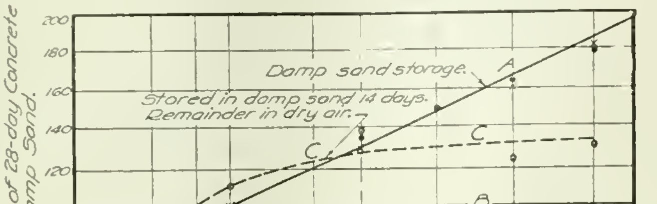


Fig. 2.—Relations Between Age and Strength of Concrete Cured Under Different Conditions.

Water is necessary for the continued hydration of cement. Consequently, if the concrete dries out there is little or no further increase in strength. This shows the importance of keeping concrete moist for several days after it is placed. Tests reported in our Bulletin 2, "Effect of Curing Conditions on the Wear and Strength of Concrete," showed that the presence of moisture during the first few days exerted a most important influence on both the strength and wearing resistance of concrete.

TABLE I—EFFECT OF AGE ON THE STRENGTH OF CONCRETE.

Compression tests of 6 by 12-in. cylinders.

Twenty-eight-day strength of specimens stored in damp sand (or moist air) considered as 100 per cent.

Mixtures 1:5 and 1:4; aggregates, sand and pebbles graded up to 1½ in.; consistency similar to that used in road construction.

(A), (B) and (C) refer to corresponding curves in Fig. 2.

Age at test.	Damp sand or moist air (A). Per cent.	Dry Air (B). Per cent.	Damp sand 14 days, remainder in dry air (C). Per cent.
	Relative strengths of concrete for different curing conditions.		
3 days	25	30	25
7 days	60	55	60
14 days	80	70	80
28 days	100	85	110
2 months	120	92	125
3 months	130	93	127
6 months	150	95	130
1 year	165	95	130
2 years	185	96	130
3 years	195	..	...

A study of a large number of tests made in the Structural Materials Research Laboratory gives the relations between age and strength of concrete cured under different conditions, shown in Table 1 and Fig. 2. The values are platted to a logarithmic scale of ages. Each of the values for damp sand or moist air storage (Curve A) is based on about 100 tests made in 6 different series over a period of about 5 years. The points for Curves B and C are each the average of 15 tests. The concrete was of mixtures similar to that used in road construction.

Curve A illustrates the point made above to the effect that so long as moisture is present, the strength of the concrete is proportional to the logarithm of its age. Both Curves B and C show that no material increase in strength may be expected after the concrete has fully dried out. The strengths due to intermediate conditions of storage will fall somewhere in the region between Curves A and B.

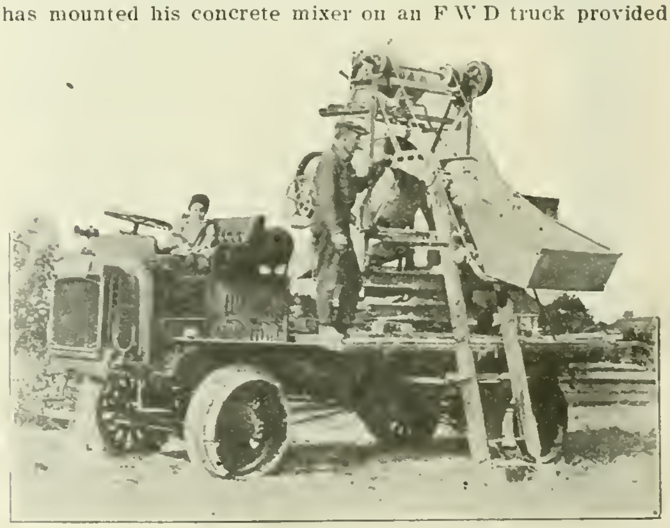
If concrete is exposed to moisture at any time after being dried out, the hydration of the cement is resumed as shown by the increase in strength of the concrete. The process of hardening is simply arrested during the period when the concrete is dry. It was shown by tests made at the University of Illinois and reported by Prof. H. F. Gonnerman in the Proceedings American Concrete Institute, 1918, page 101, that specimens which had been in dry air for 2 years showed a rapid increase in strength when placed in damp sand. In these tests there was little or no increase in strength in the air-stored specimens between 1 month and 2 years.

Another valuable report will be found in a recent paper entitled, "Effect of Age and Curing Conditions on Concrete —Results of 10-Year Tests," by Prof. M. O. Mithey, published in the Wisconsin Engineer, November, 1920, and in Engineering and Contracting, Nov. 24, 1920. These tests showed that concrete cylinders stored in forms for 3 days, sprinkled daily until 14 days old, then placed outdoors with ends in contact with damp soil gave strength up to 10 years which were only slightly less than for similar specimens stored in water for the entire period.

In roads where the concrete may receive moisture from the damp sub-grade and from seasonal rains and snows we would expect to find a gradual ascent in the age-strength curve for an indefinite period of years. There is no reason to anticipate a reduction in strength with age, even in arid regions. After a careful study of all available data on the subject, the writer can state with the utmost confidence that under normal conditions, concrete in roads does not deteriorate in strength with age.

Mixer Mounted on Truck

Mr. Stanley Carman, masonry contractor, Woodmere, L. I., has mounted his concrete mixer on an F W D truck provided with flanges, or extension rims on the wheels, to carry the outfit over soft ground, and finds that he has accomplished a considerable economy thereby. The saving in moving time and the ease of properly placing the equipment are the advantages which score economy.



Concrete Mixer Mounted on Truck.

Experiments in Improving Prairie Roads

Investigations Being Conducted at University of Alberta for Utilization of Bituminous Sand Deposits Outlined in Paper Presented at 9th Annual Convention of Canadian Good Roads Association

By DR. K. A. CLARK,
Industrial Research Department, University of Alberta.

Two closely related Alberta problems are being investigated at the Industrial Research Department of the University of Alberta, under the administration of the Scientific and Industrial Research Council of Alberta, Herbert Greenfield, chairman; namely, methods of improving our prairie roads and methods of development of the Athabasca bituminous sands. It is not obvious, at first sight, that these problems are related, yet, it seems probable that it is to the deposit of Athabasca bituminous sands that the prairie provinces should look to find the supply material that will act as a substitute for the stone and gravel material used in the making of the well-known hard surfaced roads which are missing in the prairies. The bituminous sands contain an asphalt which, when separated from the associated sand and then mixed with prairie soil, quite profoundly changes the nature of the soil and makes it resistant to the unstabilizing action of water. Natural prairie soils, if at all clayey, take up water with avidity and promptly turn into a sticky unstable mud that is the despair of both the traveler and the highway engineer.

Prairie Road Problem.—The relationship between the prairie road problem and the bituminous sands is interesting. The prairie road problem is well known; a tremendous mileage of highways; mud of the worst kind; generally speaking, no supplies of stone or gravel with which to make road surfaces; and not a large enough population or volume of traffic to warrant importation of materials to build the well-known hard surfaced roads at any cost. In connection with this road situation consider the other problem. In the north of the province of Alberta there are about 15,000 square miles of country underlain by sand impregnated by asphalt. Large quantities of this bituminous sand are in plain sight along the banks of the rivers which have cut their valleys through the formation.

This bituminous sand deposit is the largest of its sort so far found any where in the world. It is one of the big resources of Alberta. Two obstacles stand in the way of its development: first, the lack of an economical method of separating the asphalt from the sand so that the 85 per cent of sand may be left in the north and only the 15 per cent of the bitumen be shipped out; secondly, the lack of a sufficiently extensive use for the asphalt, when separated, to make feasible the establishment of development operations.

The Industrial Research Department of the University of Alberta is searching diligently for a method of separation and if present favorable indications continue favorable, it will find one. It is in regard to the second obstacle that the connection between roads and bituminous sands arises. The big use for asphalt today is in road construction. Our prairie provinces need roads. If it can be discovered that by the use of reasonably small amounts of bituminous-sand asphalt, a type of prairie road adequate to the needs of the rural communities can be built economically, then a big outlet for asphalt from a bituminous sand will be open. The solution of the prairie road problem and of the tar sand problem are tied up together.

Bituminous Sand Prairie Road.—The development of a type of prairie road with the aid of bituminous sand asphalt will depend on an understanding of the properties of prairie soils. The outstanding property of prairie soils, from the road point of view, is their mud-forming ability in presence of water. What is the reason for this mud-forming ability? Studies of soil chemists and physicists have assigned the reason to the colloid content of the soils. The term "colloid" need not introduce any mystery into the discussion. Everyday experience brings us all into contact with colloids. Two common examples are gelatine and glue. These substances are hard and stable and when dry have marked binding qualities but when placed in water they swell to unstable jellies. In many places throughout Alberta nature has concentrated a natural colloid which, if it is not the actual colloid present in our prairie soils, must be very similar to it. I refer to "bentonite."

Bentonite is a hard, almost stone-like material when dry, but in contact with water it swells to about eight times its dry volume into a sticky, unstable mass. Granted that bentonite or a similar type of substance is present in our prairie soils, it is not so hard to understand their hard, stable nature when dry and their marvelously quick change to unstable mud when they become wet. It is the presence of such a constituent in prairie soils which makes it so difficult to get a satisfactory sand-clay mixture for prairie roads. Many prairie soils are natural sand-clay mixtures, yet they soften badly when wet. The key to the situation is to find some way of modifying the soil colloid so that it will not swell in the presence of water, some way of keeping it always in its stable form.

There is a property of colloids which offers hope of accomplishing the result of modifying the soil colloid so that it will not so readily swell in water, the property of "adsorption." The term "adsorption" is probably still more mysterious than that of "colloid." There is no mystery about it however. Adsorption is a property which all matter, in the liquid and the solid form at least, possesses of condensing and tenaciously holding onto its surface a very thin layer of other substances with which the surfaces come into contact. Everybody has observed the working of this property. Why does a canvas tent shed rain? Because the dry canvas has a layer of air adsorbed onto the surfaces of all its fibres and the rain must first displace this adsorbed air before it can penetrate the canvas. Why does a shower penetrate such a little way into dry sand? Because the dry sand particles have a layer of air absorbed onto their surfaces and this air must be displaced before the sand particles can be made wet by the rain. Colloids are made up of exceedingly small particles. The result is that a small amount of colloid has a tremendous amount of surface. Since adsorption is an effect that takes place on surfaces, adsorption is a very prominent property of colloids. If a fine soil such as a clayey soil is shaken up with a dye solution and this mixture placed on a filter, the solution which filters through is colorless. The soil particles, especially the very fine colloid particles, have adsorbed the dye which was dissolved in the water and have left the water colorless. There are a host of substances that soil particles will adsorb in a similar manner to the way they adsorb the dye. If the soil particles could be brought into contact with some suitable substance, a substance, an adsorbed layer of which on the surface of the soil particles would prevent them from taking up water, then a remedy for the mud-forming propensity of soils would be in sight.

Experiments with Bitumen.—Bitumen such as asphalt is a substance which repels water. Bitumen at once suggests itself as a substance to try to get adsorbed onto soil particles. Experiments tend to show that bitumen is adsorbed by the soil particles and that this adsorbed bituminous layer prevents the soil colloid from swelling in water. When the rather soft asphalt which is separated from the Athabasca bituminous sands is mixed with a wet soil, the asphalt readily works through the soil and is apparently distributed over the surfaces of the particles. When the wet soil into which the bitumen has been mixed dries out again, it is found that it has largely lost its ability to again take up water, at least at all readily. The quantity of bitumen that it is necessary to mix with the soil to accomplish this result varies, of course, with the clayey nature of the soil.

Experiments at University of Alberta.—Experiments at the University of Alberta have been made on a series of soils including a sandy soil from the south of the province, silty soils, a natural sand-clay mix and heavy clay soils. The method of test is very simple. A sample of the soil is made sufficiently wet with water so that it can be easily worked. The desired amount of asphalt, as separated from the bituminous sands, is added and worked through the wet soil. The sample is then compacted into a small wooden box and the top rounded off to imitate a miniature section of road and set away to dry. It is then exposed to wet conditions which are created by the spray from a garden hose. Samples are placed under the spray at the close of the afternoon and the result observed the following morning. By arranging a series of samples of the same soil containing varying percentages of bitumen, the advantage gained over the natural soil by addition of the bitumen, and the quantity of bitumen which must be added to render the soil stable against the artificial rain, are at once apparent. It is found that 5 per cent by weight of the bituminous sand asphalt is sufficient for the sandy soils, from 5 per cent to 10 per cent for the silty soils, while for the heavy clay soils 15 per cent to 20 per cent is required. The bitumen for a heavy clay soil appears to be excessive. However, in a practical application, the proper procedure would be to make a sand-clay mix and incorporate into the sand-clay aggregate 5 per cent of the bituminous-sand asphalt. The sand for admixture would not need to be a coarse sand, as is required for ordinary sand-clay construction, for the bitumen-treated clay will be stable under wet conditions as well as under dry conditions. If this scheme proves to be of practical value the prairie road type may become, not the sand-clay type, but a modification of this type, a sand-clay-bitumen road.

Use of Bitumen in a Soil Mixture.—The idea of using bitumen in a soil mixture especially in the way that has been described may seem novel to many but in reality it is not new. Oiling earth roads has been quite extensively practiced and has met varied success. A type of pavement called the "Bitumenized Earth Pavement" was proposed a few years ago in the United States. It was made by incorporating about 17 per cent of asphalt into dry, pulverized clay soil. The Bureau of Roads Progress Report for 1916 gives an account of an experimental piece of road construction very similar indeed to what we have been discussing. Hot asphalt was mixed into wet clay. The results were rather encouraging but the idea was not carried to a definite conclusion. Bitumen is also being used by the U. S. Bureau of Roads in experiments to stabilize subgrades for pavements.

We do not claim any great share of originality for the work being carried on at the University of Alberta on the road problem. It is simply a case of trying to apply what has already been found out and what little else we can ourselves find out to local conditions which we have to face in our prairie provinces. Nature has not provided us with the material to build the well-known types of hard surfaced roads and we cannot afford to import these materials. Yet we need something better than the plain dirt roads, when the weather turns wet. If most prairie roads could be made to stay as stable when wet as they are when dry, our roads would be plenty good enough for our needs for some years to come. If we can get the asphalt out of the Athabasca deposit of bituminous sand cheaply, I believe that through its use it will be possible for the prairie provinces to make economical roads that will be serviceable whether it rains or shines.

Civil Service Examination for Highway Research Specialist.—The U. S. Civil Service Commission, Washington, D. C., has announced open competitive examinations for highway research specialists, grade 1, $1,800 to $3,000 per year, and grade 2, $3,000 to $4,500 per year. Vacancies in the Bureau of Public Roads, Department of Agriculture, Washington, D. C., will be filled from this examination. The duties of these positions involve investigations in the laboratory, field and office having to do with questions of design, construction, materials, maintenance and economics as related to highway improvement and highway transportation. The appointee will be required to direct such investigations or to conduct them in person. Applications for the examination will be received until Sept. 12.

An Effective Danger Warning Sign.—Over a particularly smooth innocent-looking section of road in the Dixie Bee Line Highway in Tennessee swings a 40-ft. sign bearing the inscription: "Drive Slow—Dangerous as the Devil." This sign has had its effect for residents there say only one fatal accident has occurred along that piece of road in 10 years—and as one old-timer tersely put it, "That durn fool was full o' mule, had a 3 to 1 gear on his flivver and couldn't read anyhow." Less than 400 ft. from the sign with the skull and crossbones warning are two hidden, blind, narrow almost 90 degree turns, not curves, bearing right and left.

American Society for Municipal Improvements Convention.—This society is to meet in convention at the Hollenden Hotel, Cleveland, O., on Oct. 2 to 6, inclusive. The office of the society is 830 Engineers' Bldg., Cleveland.

Road Building in Panama

An interesting description of road building conditions on the Isthmus and the plan of financing and constructing new roads was given by J. W. Beardsley, chief engineer of the Central Highway Commission in the March issue of The Cornell Civil Engineer. We quote from his article as follows:

The Highway Commission.—Early in 1920 a law was also enacted creating a Central Highway Commission of five members, of which the secretary of public works was made, ex-officio, the chairman and the fiscal agent a member. One of the other members was required to be an engineer and was designated as the chief engineer and executive officer of the commission. The engineer and the other two members are appointed by the president of the Republic who also appoints all other employes except laborers. Although the commission was vested with full authority, by law, over all matters pertaining to roads and bridges, this appointing power vested in the president tended in a large measure to relieve the members of any personal responsibility, and to make the work of the commission political and expensive rather than technical and economical.

The organization of the commission was completed during the summer of 1920. Its first work was to outline a system of public roads and to select those to be first constructed and then to prepare specifications on which to base construction contracts. As practically no Panamanian engineers and contractors were available who were experienced in road work, it was decided to include surveys, designs and construction in the first contracts on the basis of a "cost plus percentage" contract and to make the amount involved sufficiently large to be attractive to responsible and experienced firms.

Funds.—The government had collected nearly $3,000,000 in its road fund by the latter part of 1920 and it was estimated that the annual increment would be approximately $1,250,000. No engineering data were available regarding floods and stream discharges, the location of materials suitable for roads, the topography of areas to be traversed, etc. While some investigations were started, the prevailing opinion was strongly opposed to any expenditures for technical studies and to any delays in starting actual construction. Fortunately an excellent laboratory was available on the Canal Zone for testing road materials including bituminous mixtures, mechanical analyses of aggregates, etc., as were also extensive machine shops.

While the economy of one contract was fully appreciated it was considered advantageous for political reasons to prepare two contracts and $3,500,000 was decided upon as the amount to be expended under each contract during a period of about four years. As several Panamanian engineers and contractors would, probably, be then more or less experienced in road work, it was expected that future contracts would be based on surveys, designs and estimates of quantities made administratively and that bids would be called for on the basis of unit prices on the construction items involved.

Specifications.—A discussion of a few of the special points in the specifications will be of interest and value.

A large guaranty of $100,000 in cash or certified check was required of each bidder in order to exclude irresponsible bidders. This guaranty of the successful bidder was converted into a small performance bond which might be based on approved mortgages.

The contractor's expenses to be covered by the percentage bid were defined in detail. The principal items were all promotion, legal and banking expenses, all administrative expenses outside of the Republic and all expenses of associates who might occasionally visit the works. It included damages and losses of equipment due to neglect on the part of the contractor and the loss of equipment in transit which the contractor was expected to cover by marine insurance.

The contractor was required to purchase all necessary equipment approved by the engineer. Cost of equipment included all expense incurred up to its delivery at the site of the work, and the percentage was computed on this cost.

(Note: Paragraphs in the specifications relating to the purchase of equipment and materials outside of Panama should have stated a fixed purchasing commission to be paid the purchasing agent whether the contractor or otherwise and should have provided for making purchases jointly with a representative of the government at the option of the government.)

The law required and the specifications clearly indicated that the contractor should shelter and subsist his employees in sparsely inhabited regions.

(Note: Provisions should have been made for a more complete control by the engineer of subsistence as a means of increasing the health, endurance and efficiency of laborers. This provision is of special importance in Panama where the laborers are weak and inefficient on account of inferior and unbalanced rations, and the prevalence of malaria and hookworm.)

Provisions were made for the prompt payment of the contractor's certified and approved bills. If payment was delayed on monthly accounts more than 15 days the contractor was allowed interest at the rate of 8 per cent per annum.

Details of construction were controlled by the Illinois "Specifications for Road Work" dated January, 1920, and those for "Bridge Work" of April, 1920, in so far as they were applicable.

(Note: These detailed specifications conform closely to the tentative specifications of the Bureau of Public Roads, Washington, D. C., which would have been used, if copies had been available, as standard methods of construction.)

The usual power to inspect the contractor's accounts and to control the successive steps of surveys, designs and the preparation of the estimate by the contractor was vested in the engineer. The percentage was computed on the actual cost of such work.

The contractors' estimate was based on quantities and unit costs of construction items including 10 per cent for contingencies and an equitable proportion of expenses of administration, but not including cost of equipment, surveys and other investigations necessary to preparing an estimate. When this estimate which was subject to a joint revision was approved by the engineer, it was defined as the "officially adopted estimate" and was the base for computing the percentage.

Costs.—If the actual cost of construction exceeded this official estimate the loss was to be equally divided between the government and the contractor up to one-half of the contractor's percentage. Further loss was to be carried entirely by the government. If the cost was less than the estimate, then the savings were to be equally divided up to a total saving of 20 per cent and any further savings were to the account of the government. For example, if the contractor's bid was 8 per cent, then his possible minimum percentage on construction costing eight or more per cent more than the official estimate would be four per cent of the official estimate and his maximum percentage if the actual cost of construction was less than 80 per cent of the official estimate would be 8 per cent plus 10 per cent or 18 per cent of the estimate.

In case of disagreement methods of arbitration were specified, one arbitrator to be appointed by the commission, one by the contractor and the third by these two arbitrators. (No provision was made in case of a dead-lock.) Their decisions were to be final and binding, the contractor agreeing not to resort to diplomatic procedure. Each party was to pay the fee of its arbitrator and prorate other expenses of arbitration proportional to the difference between the sum fixed by arbitration and their respective claims.

From the above notes on a few of the paragraphs of the specifications it is evident that the successful operation of these "cost plus percentage" contracts depended in a large measure upon the capability, fairness and honesty of both parties to the contract.

Bids.—Advertisement for proposals were made Jan. 3, 1921, for a period of 45 days. Copies were distributed to the Panamanian Consuls in various foreign countries and published in local papers and in the Engineering News-Record. Two contracts were awarded in March, one to an American and one to a Panamanian company, the percentage bid being 5⅓ per cent and 9 per cent respectively. The length of the preliminary routes selected for survey and construction was about 135 kilometers located in the central provinces having the greater agricultural development and the larger population. Both companies commenced work promptly. The government unfamiliar with such contracts was inclined to modify and change certain important paragraphs of the specifications regardless of the terms of the contract. Such changes might have benefited several small local firms but would have been serious for the contractors. They deprived the contractor of his rights to make the authorized purchases, to subsist his employees and to select and fix the salary of his employees. These differences were finally adjusted during the fall of 1921 to conform closely with the contract ratified in March, especially in the case of the American firm which had done excellent technical work and had strictly complied with the letter and the spirit of the contract.

In general the main trunk lines must parallel the coast and the expenses for bridge construction will be heavy. The Republic is not within the typhoon or hurricane belt. Its rainfalls are of short duration but of intense rates. Special studies are necessary of the runoff of each drainage area in a region of such heavy precipitations and the only reliable data were the records of the Panama Canal. The annual rainfall of the Pacific side is slightly more than one-half of that of the Atlantic. The proposed roads are all located on the Pacific side and it was estimated that a maximum daily runoff of nine centimeters for small areas of moderate slopes should be provided for. This runoff may be doubled for culverts draining small steep areas and reduced to three centimeters for the larger rivers.

Type of Road.—The general type of road selected for construction where so little traffic has been developed was a macadam road with three and one-half meters of surfacing and shoulders one and one-half meters wide, to be ultimately developed into a macadam or concrete surface four and one-half meters wide with shoulders of one meter when increasing traffic merits such construction. While the rapid introduction of autos and motor trucks will immediately follow road construction, their number will be relatively small until agricultural production has been greatly expanded. In the meanwhile the people must learn to use roads, to shoe draft animals and to adopt wider tires for their ordinary traffic which will continue to be of local importance for several years. They must learn how to maintain roads and to provide maintenance funds by methods that can and will be enforced. It is an extravagant, wasteful policy for any country to construct a system of roads without providing for their efficient maintenance, a policy which must quickly result in a dismal failure and in a serious delay to any progressive plan for road construction.

Another type of contract based on unit prices was prepared covering 10 kilometers of road. The first 4 kilometers were concrete 6 meters wide and the remainder bituminous concrete 5 meters wide The first portion was adjacent to a street railway and practically a city street, the principal approach to the city of Panama from the east. The maintenance of the old macadam road, built of an inferior grade of stone, had been shamefully neglected. The right of way had been seriously constricted. In some places fences had been built between the roadway and its ditch. On account of the importance of the location of this road it was proposed to make possible the ultimate construction of a street suitable as an approach to the Capitol of the nation. Surveys and designs were made administratively. The design required a width of right of way sufficient for the construction on the opposite side of the street car tracks of another concrete section also 6 meters wide exclusive of the space required to double track the railway. It also provided for sidewalks and for laying sewers and water pipes without breaking the pavement. Thanks to the generosity of the adjacent property owners, after an educational propaganda showing the profitable future effect of such improvements upon the value of adjacent land, the necessary additional right of way was secured without cost to the government. This wider right of way was required only for the 4 kilometers of the concrete section. This contract called for the construction of one-half of the proposed street, the construction of the other half and the adjustment of the street railway being postponed until additional funds were available and the development of traffic merited such expenditures. The concrete section was practically completed early in September and the asphalt section at the end of the year.

This type of contract based on the unit prices submitted by the bidder, the government making all preliminary investigations, designs, estimates of quantities and securing the necessary right of way including quarry sites with their access roads, etc., removes many uncertainties and is generally the more satisfactory.

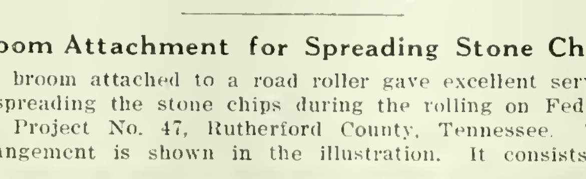
During 1921 the Highway Commission reconstructed administratively some 12 kilometers of macadam road, an extension of the above described road leading out of Panama. A few investigations were started, several structures repaired and a reinforced concrete bridge built. It also took over the extensive repair of about 30 kilometers of an isolated railroad located in the extreme westerly part of the Republic, the maintenance of the roadbed and rolling stock of which had been so utterly neglected that the operation of the road was no longer safe. This work was nearly completed by the end of the year. The Commission will operate the road for a couple of years in order to reorganize the entire management and eliminate many serious defects that had characterized the previous political management.

It is intensely interesting to the engineer to be able to start new work which means so much to the future development of the country, as do good roads in Panama where the volume of work done compares favorably with that done by our states during the first period of a good roads policy. There is a real danger of neglecting necessary technical investigations in carrying on construction too rapidly in order to meet a common popular demand. This danger was greatly reduced in Panama by the assistance available in the laboratories of the Canal Zone.

The serious remaining danger is a failure to maintain the new roads. Panama has never learned the first principles of maintenance. Upon the completion of the "cost plus percentage" now in force there should be available a sufficient number of Panamanians trained in both the construction and maintenance of roads. Until that time is reached the governments should continue to employ foreign experts.

Broom Attachment for Spreading Stone Chips

A broom attached to a road roller gave excellent service in spreading the stone chips during the rolling on Federal Aid Project No. 47, Rutherford County, Tennessee. The arrangement is shown in the illustration. It consists of ordinary brooms attached to two-by-fours connected with a strap hinge, which permits the broom to conform to crown of the road. The broom can be attached to the scarifier as shown or to the roller with a hinged connection, which allows the broom to rest its own weight on the pavement.



Broom Attached to Roller.

Truck Haul vs. Team Haul on Oklahoma Road Job.—An interesting comparison of team haul and truck haul has been made in the Oklahoma Highway Bulletin. A highway contractor while doing State aid road work of hauling crushed stone employed seven teams, seven drivers and one $3\frac{1}{2}$-ton motor truck. The seven teams had each hauled three loads of $1\frac{1}{2}$ yd. per day, a total of $4\frac{1}{2}$ yd. daily, or $31\frac{1}{2}$ yd. for the 7 teams. By motor truck he hauled 33 yd. each day. Figuring the cost of each team and driver at $7.25, the total amount was $50.75 per day for seven teams. The $3\frac{1}{2}$-ton motor truck actually hauled more material each day than seven teams. The operating expenses of the motor truck amounted to $18.40 per day, thereby effecting a daily saving of $32.25.

Road Construction in Prairie and Timbered Country

Methods Used in Province of Alberta Canada Described in Paper Presented at 9th Annual Convention of Canadian Good Roads Association

By J. D. ROBERTSON,

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Local conditions make it rather difficult to apply a uniform method of road construction to the Province of Alberta as a whole, running as it does into the foot hills and mountains on the west, timbered country with occasional swamps and muskegs to the north, and rolling and level prairie to the south and east. Soil conditions also vary a great deal. Generally speaking the soil is excellent for agricultural purposes, but the better it is in this respect the less desirable it is as a road building material. In view of these facts you will no doubt appreciate our difficulty in preparing specifications for construction of roads applicable to the entire province. If, on the other hand, it was sufficiently developed to warrant hard surfaced construction we could ship the required material by rail if necessary and thus adopt uniform methods of construction.

For this reason we must follow the method of construction, which in our opinion is best adapted to local conditions and controlled by the amount of money available for the work. In stating how to improve sand, clay and earth roads, as I cannot outline in detail any particular method applicable to Alberta as a whole, I will choose our two extreme conditions, that is the method we adopt in open level prairie, and on the other hand the method followed in fairly heavy timbered country to the north end of the province.

Road Grading Over Open Level Prairie.—First let me deal with our method of road construction in level prairie country; all material for crown being obtained from the side ditches. We usually construct our more important main highways a width of 28 ft. between the outside of ditches. Others that are not required to carry as much traffic are very often constructed 26 ft. between ditches, and the local roads carrying still less traffic have a width of 24 ft. This provides a traveling surface of 20 ft., 18 ft. and 16 ft. respectively. Where any of the above mentioned roads carry excessively heavy traffic, as leading into a city or large business center, the width may be increased by not more than 2 ft.

In constructing a main highway 28 ft. between outside of ditches two lines of stakes are set 28 ft. apart, equal distance from center line of road allowance. When the tractor which provides the power required, is used for hauling a heavy 12 ft. blade grader, plowing is not necessary. The first round trip is made down one line of pickets and back the other which constitutes one round or two running-miles for each mile road graded. In the first round the outside end of the grader blade is dropped well down and forward, which cuts very much as if it were a plow. In the second round the position of the blade is changed slightly so that on this trip the material is pushed to within 1 ft. of the center of the road. Generally speaking we now have all the sod that is to be moved in the center of the road overlying the center 18 ft. of 20 ft. of original prairie sod which has not been disturbed. The third round is a second plowing with the blade grader in the side ditches, this material being fairly free from sod. The fourth round again pushes this material to within about 1 ft. of the center of the road, covering the sod. The fifth round pushes the material to the center of the road, but instead of the road being suitably crowned it usually comes to a peak in the center, more in the shape of a roof. A further trip one way is therefore necessary, which is carried out by setting the grader blade straight across the road and proceeding to the end of the new grade. Camp is usually moved at this time by hauling the cook car and other equipment behind the grader. The grader removing the ridge from the center of the road and giving the road the necessary crown, and at the same time makes wheel marks in the center of the new grade, which acts as a guide to traffic following. The last trip constitutes ½ a round making $5\frac{1}{2}$ miles all told, or 11 running-miles for each mile of road graded.

I might add here that we consider $5\frac{1}{2}$ miles the maximum required and very often $4\frac{1}{2}$ is sufficient for a road 28 ft.

between ditches, and is invariably sufficient for a road 26 ft. or less between ditches. Work of this nature should usually be done in the spring or early summer when there is sufficient moisture in the ground so that the grade will consolidate, for it is absolutely useless if carried out after midsummer during a dry year, as there is nothing but a pile of dust through which it is impossible to travel.

Cost of Grading.—The Government owns all graders used for work of this nature, but does not own the tractors. We believe it is more economical to run the tractors on a mileage basis, paying $9 to $10 per running-mile for the use of the tractor, including cost of operation and repairs. The department usually pays the man who operates the grader, he being held responsible for bringing the grade to the proper cross section and keeping a record of the number of miles made by the tractor. This work would, generally speaking, average from $90 to $100 per mile and for this amount we obtain an 18 ft. to 20 ft. surface for traffic with a side ditch 15 in. to 18 in. deep.

Further work may be necessary to provide a road surface suitable for traffic, depending entirely on the nature of the soil. It may be necessary to use a disc or harrow to cut sod or break down lumps, and use a road drag to level the surface. In other sections of the country it may also be necessary to remove rocks from the grade. When such is the case they should be cast well outside the ditches.

With this method of road construction the grade line of the side ditches conforms to the contour of the ground surface and does not likely provide for carrying surface water to drainage outlets, but is liable to form pools in every depression. It is therefore necessary to bring the side ditches to a grade line that will prevent the water lying along the grade. It is also important that all necessary culverts be installed. They should be put in immediately after the grading is completed so that the fill over the culvert will properly consolidate with the road bed.

The cost of such road including culverts and ditches over fairly level prairie would run approximately $300 per mile, depending of course on the number of culverts required and the amount of drainage necessary. In passing I wish to draw your attention to this fact that the traveling surface provided is only of material taken from the side ditches, such as it is.

Road Construction Through Timbered Country.—I will now deal with our method of road construction in the timbered portion of the province, assuming that all material for grades is obtained from the side ditches and that the distance between outside ditches is 28 ft. We first must locate our property line and usually stake out the central 33 ft. of the road, which is cleared and grubbed. In clearing various methods are followed, but I believe the one giving the most satisfactory results is that of cutting the trees off about 3 or 4 ft. up from the ground. This gives an opportunity with a block or team, depending on the size of the trees with hitch near the top of the cut off, to pull out the stump. If they are any size it is usually advisable to first shoot a stick of stumping powder under the stump which loosens the stump, but the principal benefit derived is that it jars the earth loose from the roots so that when the stump is pulled out it comes out clean and without bringing a large quantity of earth with it.

All stumps, roots and other fibrous matter are cleared from the central 33 ft. of the road, which is absolutely necessary to permit the grader to do its work. The cost of clearing and grubbing is generally figured on an average basis, varying from $10 to $50 per acre, depending entirely on the class of timber to be cleared. In heavy spruce it might cost even more than $50. However, the timber is not generally heavy in northern Alberta, being mostly light poplar. A fair average I believe for this kind of material would be $25 per acre for clearing and grubbing the central 33 ft., which means an expenditure of $100 per mile with an extra $15 an acre for clearing only, the balance of the road allowance being an expenditure of $160 per mile for clearing the entire width of road allowance and grubbing the central 33 ft. This is only an average, as we have had instances where this work would cost up to $1,000 per mile. The brush, roots, etc., are piled and burned.

We next grade the road with an 8 ft. horse grader, hauled by at least 4 teams. It is usually necessary to first plow two or three furrows on each side of the road. The material is then pushed in with the blade grader after the same manner as is done in prairie grading, except that the same progress cannot be made, more trips are usually necessary owing to the small roots encountered. It is invariably necessary to disc the road well after grading and again trim it up with a grader to obtain the necessary crown, which would likely cost $125 per mile. Further work to improve such a road and open it for traffic would depend entirely on the nature of the country.

The clearing, grubbing and grading I have referred to will only answer where the ground is high and dry and naturally well drained. Usually however besides drainage and installing culverts there is considerable other work to do such as laying corduroy or brush and making cuts or fills.

Brush and Corduroy Roads.—In connection with corduroying, the material is cut 16 ft. in length and laid side by side across center of road. Where the material can be obtained within ½ a mile the cost is about $2.50 per rod, which is at the rate of $800 per mile. This is only used in passing over musked or low land that will not support an earth fill. A willow brush mat of the same width, laid 12 to 15 in. deep can be done for about the same price. Willow brush is laid with tops overlapping in the center of road. The brush tops from one side of the road are carried throughout as a lower layer and the tops from the other side forming an upper layer so that when the brush is being covered the teams can then swing with brush tops. This is a very important feature in laying brush and the proper laying of the brush greatly reduces the cost of filling. Brush and corduroy is usually only necessary for a short stretch and therefore only represents a small percentage of the total mileage being worked. I might state that generally in fairly heavy timbered country it would cost about $150 per mile for brushing or corduroying. We then have installing culverts and making fills, and, most important of all, ditching, as drainage is the all important feature especially constructing roads in a timbered country. The main feature we always keep before our men is to get the water off. The cost of improvements of this nature would run from $600 to $1,000 per mile in timbered country such as exists in northern Alberta, which invariably includes stretches of low land required to be brushed and corduroyed. We, therefore, might easily strike our average $800 per mile.

I first dealt with road improvement for prairie country and arrived at an estimated cost of $300 per mile. Through timbered country the cost is $800 per mile. The balance of the province will vary between these two amounts, depending on the nature of the country through which the road passes. In either case what have we got? Principally a road constructed of material taken from the side ditches, such as it is, which presents a traveling surface that if properly dragged throughout the season is a very fair road to travel upon during dry weather. But during the wet weather there will be many sections of road that would not carry traffic without injury to the road and danger to those attempting to travel. When the soil obtained from the side ditches is of sand, fine gravel, or a sand clay mixture a very fair traveling surface is provided even during wet weather. On the other hand, where the soil is exceptionally light it is quite satisfactory in wet weather, but is not at all suitable in dry weather. Again, where gumbo or heavy black loam is encountered one usually endangers his life by trying to drive a motor vehicle over it after a rain, and after a period of wet weather the traffic will ruin for the time being this portion of the road.

Road Mileage of Alberta.—We have in Alberta approximately 15,800 miles of continuous graded roads and 28,500 miles approximately of road where the necessary culverts have been installed, fills made where necessary, but not continuously graded throughout as the drier sections carry traffic without further improvement. We have approximately 12,500 miles of regular road allowance which can be traveled and upon which no improvements have been made, with an additional 3,000 miles of angling trail temporarily used in lieu of regular roads not yet opened. We therefore have approximately 60,000 miles of graded road or trail in use at the present time with another 80,000 miles of regular road allowance in the fairly well settled portions of the province, which have not yet been opened for traffic, which serves approximately 100,000 resident ratepayers outside of the cities, towns, villages or hamlets. Of the 15,000 miles of continuous graded roads, a very small percentage, possibly not over 300 miles all told, have been surfaced with material other than that taken from the side ditches or where fills have been made the material borrowed from the adjoining knolls.

In Alberta gravel is scarce, while there are isolated deposits of gravel they are so scattered that the cost of haulage practically prohibits their use at our present state of development. I feel, however, that our solution is the mixture of sand and clay, as in the sections of our roads where we encountered a sand clay mixture in the proper proportion, a fairly good all weather road is provided.

In conclusion I wish to state that we have about 3,000 miles of main highway, which carries fairly heavy motor traffic from early spring until late autumn, together with an equal mileage of main market roads, which are not standing up under the traffic which they must accommodate. It is apparent that for these roads at least we must provide a more suitable wearing surface than that obtained from use of material from side ditches.

An old prairie trail is all that could be desired for very light traffic, but as soon as traffic increases beyond its carrying capacity it is absolutely useless. The same applies to our roads built from the side ditches regardless of quality of material used. Our problem in Alberta at the present time is to devise ways and means of further improving the wearing surface of our earth roads with the material available for the purpose, such as gravel or sand clay, always keeping before us the vast mileage to be improved and the extent to which Alberta is developed at the present time.

Estimating Cost of Highway Bridges

Useful suggestions on preparing estimates for the construction of highway bridges were given by Walter S. Todd, Assistant Bridge Engineer of the Illinois Division of Highways, in a paper presented at the last annual short course in highway engineering at the University of Illinois. The paper follows:

A good estimate is one which approaches very closely to the actual cost of construction, with a fair profit to the contractor included. In order to secure accurate estimates, actual cost records of similar work should be available to the estimator.

There are two factors which have made it difficult to secure reliable estimates on highway bridges; first, the construction of bridges of the types now common, and by the method now prevalent is comparatively recent, so that cost records are not available which are applicable to present types and methods of construction. Second, the securing of actual costs while construction is in progress involves extra work upon the engineer in charge of the work, and consequently is generally slighted. The time and energy required to "boil down" cost records to a unit basis, so that it may be used on similar work for estimating purposes, is very great. The results obtained, however, are worth the effort and form a basis for estimating.

Preliminary Estimate.—There are two kinds of estimates—preliminary and final—and each has its particular field of usefulness. A preliminary estimate may be based upon approximate data, but with sufficient information at hand, it should not vary greatly from an estimate which is made after the detail plans are complete. A preliminary estimate may be based upon plans for structures of a similar nature which have already been prepared, or upon standard plans. Curves may be prepared which show the relation between size of structure and volume of material required, and the amount of material required for a given structure quickly obtained from them.

The preliminary estimate has three distinct uses. It may be used to determine the most economical span length to adopt for a multiple span structure. It may be used in reconnaissance for determining the most economical route to choose between two fixed objectives, i. e., the cost of earth work, pavement and bridges on one route may be compared with the same items on another possible route.

The preliminary estimate permits the determination of the approximate cost of structures without the aid of complete plans. An estimate of this kind is also essential to present a definite basis for a campaign to secure funds to finance construction, and is generally demanded before completed plans are available.

Final Estimate.—The final estimate is made after surveys and plans are completed, and should represent the engineer's best judgment regarding a reasonable final cost of the structure to the public or owner. An estimate may be quite accurately made if it is subdivided into the various items of material, labor, transportation, etc., which are involved in the construction. As an example, the following items are covered in an estimate for a reinforced concrete bridge, and each item is given in terms of 1 cu. yd. of concrete in the finished structure: (1) cement equals the number of barrels per yard of concrete multiplied by the sum of the cost of cement f. o. b. nearest station, and the hauling cost from station to bridge site; (2) fine aggregate equals volume of sand per yard of concrete multiplied by the sum of the cost of sand f. o. b. nearest station and the hauling cost; (3) coarse aggregate equals volume of stone or gravel per yard of concrete multiplied by the sum of the cost of coarse aggregate f. o. b. station and the cost of hauling same; (4) form and falsework lumber; (5) labor required in placing forms and falsework; (6) labor required in mixing, conveying and spading concrete; (7) reinforcing steel delivered at the bridge site; (8) labor in bending and placing steel; (9) removal of existing bridge; (10) excavation cost per cubic yard of concrete; (11) incidentals such as name plate, expansion device or brick for hand hails, when used. The sum of these items may then be multiplied by the total yardage in the structure and a percentage added to same to cover liability insurance, profit, contingencies, superintendence and overhead.

It is generally best to add the cost of piling as a separate item, as the cost of this part of the work is not generally accurately known in advance. The contractor may be instructed to submit a unit bid and payment may be made upon the lineal feet actually driven.

Cost Data on Illinois Bridges.—It is a comparatively simple matter to determine the quantities of material requiring for a structure, but the cost of labor is best determined from previous work of a similar nature. These labor costs should preferably be in terms of man-hours, so that variations in labor rates may be easily applied. The bridge office of the Division of Highways of Illinois has kept records of labor costs for a large number of highway bridges of various types which have been built from standard plans. These average costs in terms of man-hours per cubic yard of concrete in the finished structure are given in Table I with the number of bridges of each type from which cost records were taken to obtain the average given. Bridges on which labor items were exceedingly high or low were not included, so that the figures shown give a fairly reliable average under usual conditions for the State of Illinois as a whole. The amount of form and falsework lumber required is also shown in the table, but these figures are probably low, as the falsework used was generally green timber cut near the bridge site and was not included in the figures shown.

In Table I all structures considered had reinforced concrete abutments, with the exception of the structures listed in the last column.

Estimating Cost of Steel Bridges.—In the estimate of the cost of structural steel superstructures, the principle of dividing the estimate into the various labor, material and transportation costs is advisable. The chief items involved, exclusive of floor, in the cost of a steel truss are as follows: mill or warehouse price of structural shapes; freight from mill or warehouse to fabricating shop; fabrication costs, including detail plans, reaming, shop paint; freight from the fabricating shop to station nearest site; unloading and hauling to the proposed site; falsework; erecting; field riveting; field painting; liability insurance; profit and contingencies.

TABLE I.—COST DATA FOR REINFORCED CONCRETE HIGHWAY BRIDGES.

Type of Structure.	R. C. box.	Slab bridge.	Thru girder bridge.	Deck girder bridge.	Plain concrete abut'ments.
No. of bridges considered	83	93	48	3	5
Man-hours Per Cubic Yard of Concrete.					
Building forms	4.24	4.41	4.71	7.01	2.69
Mixing and placing concrete	3.97	4.65	4.33	3.87	3.45
Bending and placing steel	0.68	0.75	1.51	1.24	....
Feet B. M. Per Cubic Yard of Concrete.					
Form and falsework lumber.....	24.20	16.53	17.51	20.23	10.00
Pounds Per Cubic Yard of Concrete.					
Average amount reinforcing steel in superstructure	100	198	230	255	....
And substructure	100	44	53	57	....

Selection, Arrangement and Planting of Road Side Trees

Some useful information on roadside tree planting was given by C. F. Boehler, Landscape Engineer of the Michigan State Highway Department, in a recent issue of Michigan Roads and Forests, from which the notes following are taken.

Successful planting of trees depends upon several factors among which may be mentioned the following:

A—Selection of suitable varieties and their proper arrangement.

B—Preparation of the soil.
Proper planting.
Protection and care.

Selection of suitable varieties depends upon the climate, soil and the intended use of the trees, their comparative freedom from insect pests and plant diseases or other objections. In general, only those varieties growing natural in the region should be used as they have proven their suitably to the climate and soil conditions and usually are more free from insect pests and plant diseases.

Arrangement for Highways.—There are two general types of arrangement for highways, formal and informal. The formal arrangement consists of planting in regular rows and is best suited to cities and villages of thickly populated farming districts where the ground is comparatively level. While there is no invariable rule as to the distance apart, the trees should be planted so that there will be an allowance for full spread of the tree at its approximate maturity. The informal planting consists of the planting of trees in irregular groups such as one would expect to find growing naturally along the roadside. This arrangement is generally the best to use, especially in hilly or rolling regions, along rivers, lakes, etc.

In highway planting consideration should be given to the existing and future telephone and power lines. If no lines exist at the present time it is best to plant near the extreme edge of the 66 ft. right of way. In all cases planting should either be done at the edge of the right of way or about 10 ft. in towards the center line.

Varieties of Trees for Michigan Conditions.—The following list is intended as a guide in the selection of varieties to meet the climate and soil conditions of Michigan; the oaks, birches, nut trees and all evergreens should be planted in the spring only:

Variety.	Size to transplant in feet.	Soil.
	Shade Trees.	
American Elm	6-12	Clay loam
Hard Maples	6-12	Gravelly loam
Oaks	5-10	Sandy loam
Basswood	6-12	Clay loam
Birch	4-8	Sandy loam
Sycamore	6-12	Clay loam
White Ash	6-12	Clay loam
	Nutt Trees.	
Black Walnut	3-6	Gravelly loam
Beech	3-6	Gravelly loam
Butternut	3-6	Sandy loam
Chestnut	3-6	Clay loam
Hickory	3-6	Clay
	Evergreens.	
White Pine	2-4	Sandy loam
White Cedar	2-4	Muck or moist loam
White Spruce	2-4	Clay loam
Hemlock	2-4	Gravelly loam

Suggestions for Transplanting.—To insure success in the growth of transplanted trees it is necessary to do all parts of the work properly. The success of the planting is not only measured by the percentage of trees that live but also by the vigor of the trees and their consequent resistance to insect pests, diseases and other enemies. If the trees are to be dug locally and replanted, great care must be taken to keep the roots moist, especially the Evergreens, which are much more difficult to transplant than the deciduous trees, as the slightest wind through the unprotected roots will cause the drying up and killing of the small hair-like roots through which the tree draws its supply of water.

If the stock is obtained from a nursery, as soon as the trees are received and during delivery the boxes or bales should be covered with a tarpaulin, blanket or otherwise to keep off the wind. Ordinarily, as soon as the trees are delivered to their destination they should be unpacked heeled-in without exposing their roots to the wind, sun or freezing temperature. Dig a trench in a well drained location, preferably in the shade, open the bundle and separate the trees, then lay them close together with the roots in the trench and the tops on an angle of approximately 30 and cover the roots and part of the stems with mellow earth deep enough to keep them from drying out and so that no air spaces are left. The trees can be left in this position for some time without injuring them until ready to plant them permanently. (Fig. 1).

Preparation of Trees for Planting.—To prepare the trees for planting, cut off the ends of all broken and bruised roots with a sharp knife in a slanting direction on the under side. Prune the tops of all deciduous trees by cutting away from ½ to ⅔ or even more of the last season's growth, to balance the roots that were removed in handling and at the same time to properly shape the trees. Such cutting should be done just above the buds. In cases where the roots are heavy, less pruning is necessary.

Planting of Trees.—In preparing the soil, under ordinary conditions on sod land the hole should be dug at least 12 ins. deeper and 6 ins. wider than is necessary to accommodate the roots without crowding. Some well rotted manure should then be thoroughly mixed with the soil and placed at the bottom of the hole, covering this with at least 2 inc. of mellow earth to keep the roots from coming in direct contact with the manure. When the subsoil is heavy clay or hardpan it should be loosened up to a considerable depth, or if the top soil is very thin or is a sterile clay or sand the soil should be removed from an area of 6 ft. or more in diameter and replaced with a good loam.

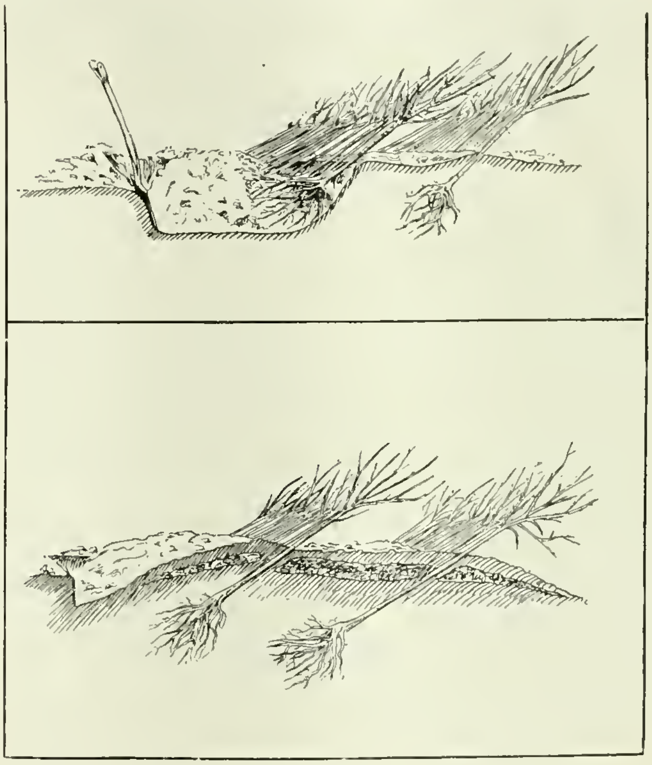

Fig. 1.—Method of Storing Trees in Heeling-in Ground.

When ready to plant, take only a few trees from the heeling-in ground at a time and keep their roots protected from drying out during the handling. The trees should be held in proper place and at a depth that will make the planted trees from 2 to 3 ins. deeper than when they stood in the nursery. Only good mellow top soil should be used for planting and this should be sifted among the roots and well tamped as the hole is being filled. When the hole is within 6 ins. or so of being full, the earth should be thoroughly packed by tamping with the heel of the foot so that the tree cannot be lifted or moved from place and so that it feels perfectly firm. Then the hole should be filled to the height of the existing surface but should be slightly dished to catch and hold the water. Loose planting is the cause of many failures and it is essential that the soil be compact about the roots. It is often advantageous to add a pail of water when the hole is half filled, especially in the late spring. In order to hold moisture during the hot summer months it is advisable to mulch the trees with sawdust, straw or manure to a depth of about 4 ins. and for a diameter of about 3 ft. As a precaution against danger by field mice this mulch should not come in direct contact with the tree.

The soil around the tree should be kept well cultivated and free from grass and weeds while the trees are young and preferably for several years after planting. Rabbits, field mice and other animals some times do a great deal of damage by gnawing the bark and girdling the young trees. Where there is any danger of damage of the kind precautions should be taken to prevent such damage by wrapping the trees with tar paper or wire netting not too tightly.

Importance of Plant Inspection in Bituminous Pavement Construction

Need for Adequate Inspection at Plant and Street Pointed Out in Paper Presented Feb. 14, at 8th Annual Conference on Highway Engineering at University of Michigan

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Anyone who has thought of this subject and is familiar with the various processes of construction regards it as an axiom that plant inspection is a necessity. It is a fact, however, that in all highway organizations there are a number of officials and engineers who have not made a special study of bituminous construction. Let us assume, for the minute, that we are in the position of an engineer who has not specialized in bituminous construction. Certain contracts have been let in his district for asphalt pavements. His appropriation is more or less limited and perhaps he is doubtful as to the real necessity for plant inspection. After the foundation has been laid and is ready for the bituminous top, he visits the plant. He finds it in operation apparently running all right, the batches being turned out and the sand assembled and fed to the dryers and the trucks are leaving with fair regularity and the mixture looks all right. It is black and the sand seems to be fairly well coated. He takes a sample from the load and tests the temperature and finds it comes within the limits of the specification requirements. From there he goes to the road where he finds the trucks delivering the hot asphaltic mixture. It is being shoveled, spread and rolled in good workmanlike manner and he comes back to his office and thinks: "What real necessity is there for an inspector at the plant?

"Everything seems to be going all right, and why visit the plant more than once a day and the street occasionally? Why is not that sufficient?" and so he lets it go at that, and if he is fortunate enough to get a good pavement he is liable to come to the conclusion that plant inspection is not a necessity but a more or less expensive luxury which can be omitted when appropriations are scanty.

There is another side of the question, however, and as I firmly believe that it is true that we learn more from our own failures and mistakes than from any other source, I am going to cite certain failures which were wholly due to inadequate inspection as possibly the best way of emphasizing the point which I am here to make.

Three Failures Due to Indaequate Inspection.—Fortunately for my illustration, within the last three years three failures of bituminous pavement have come to my attention. In all of these cases it happened that I was entirely familiar with the circumstances attending their construction and the kind of materials used and the personnel of the contractor and the engineers under whose direction these pavements were laid.

In Case I the engineer decided to limit his inspection to daily visits to the plant and street supplemented by a daily analysis of a sample taken when he visited the street. Instead of a complete analysis he determined the bitumen content only, on the theory that the amount of asphalt that went into a bituminous road was one of the most important elements to check up and that as the asphalt was the most expensive ingredient of the pavement he would be more likely to find a shortage there than in any other constituent. In this instance he was drawing on his experience in concrete construction work.

In Case II the engineer decided against complete inspection but he or one of his assistants took a daily sample of the mixture and had a complete analysis made of it.

In Case III the engineer was convinced of the necessity of plant inspection and he assigned a good inspector to cover the plant and had daily complete analyses made of the mixture but he thought the street gang could get along all right. This case is perhaps outside the limits of my subject but seems to me of sufficient importance to warrant the liberty of including it in my talk.

In Case I a single sand was used and this sand had been examined carefully and approved as suitable for the construction of a sheet asphalt pavement. In Case II two approved sands were used and they were supposedly mixed in the proportions designated by the engineer. In Case III only one sand was used and there was practically no street inspection and the street gang was composed of unskilled and incompetent men. Still keeping the preliminary conditions in mind, let us inspect these roads after they have been completed and subjected to traffic for various periods of time.

What Happened to the First Pavement.—In the case of the first road, the time will be four months. We find a small portion of it in excellent condition, a part of the remaining portion is scaling badly, and the balance of the pavement is both wavy and scaly. Remember, please, that this is only four months from the day this pavement was laid. This is no theoretical case. Less than three weeks ago I was over this particular pavement. Now, what really happened was this: An examination of the pavement from the different portions of the street showed very clearly that the portions of the pavement which were in fairly good condition carried about the normal percentage of bituminous material. The portions of the pavement that were scaling, instead of carrying between 10.5 per cent and 11.5 per cent bitumen carried on the average only 8.5 per cent. The portion which was "shoving" had about 9 per cent of bitumen. Analyses made by the engineer of this pavement all showed a bitumen content running between 10 per cent and 11 per cent, and, as you will recall, these samples were taken by the engineer on his daily visits to the street.

It developed on further investigation that owing to the pressure of other work, the engineer regularly paid a visit to the street between 10 and 11 every morning. Therefore, the men at the plant and the men on the street, after that visit between 10 and 11, knew there would be no further visits made that day and no other samples would be taken for analysis. It was very easy, therefore, for them to run during the early portion of the day a mixture which contained the normal percentage of bitumen regardless of what they did afterward.

It was also the case in this particular pavement that the contractor to whom the job was awarded was a man who had had a good deal of experience in public work, a man who stood very well with the administration, but this was his first attempt to lay a bituminous pavement. He was brought up in a school where anything to increase the output of the work could very often be gotten away with and such methods often did not seriously damage the final result, and being ignorant, he had to rely on the advice of the men he had hired for the job on the street and at the plant. They tried to make a low cost record for themselves by saving asphalt when they thought it would not be detected and by speeding up the plant.

Why the Pavement Failed.—The deficiency in bitumen was one of the causes for the failure. Another cause was the fact that the pavement was insufficiently compressed, the rolling was done superficially, and the finished pavement had a density of between 1.85 and 1.89, which is much too low. An examination of certain portions of the pavement which were defective showed that not only was the bitumen content low but the grains of sand were insufficiently coated. That led to an investigation of the record as to the daily output of the plant.

The plant had an ordinary 9 cu yd. mixer which turned out a batch of 1,000 lbs. of material. The specifications, backed up by the requirements of good practice, called for at least 1 minute's mixing in the mixer, the revolutions of the shafts between 60 and 80 per minute. An experienced mixing crew, trained to the last minute and entirely competent, can probably turn out one batch of mixture every minute and 20 seconds and give a full minute's mixing to each batch. An exceptionally well trained crew can, throughout the day, average one batch in 1 minute and 30 seconds. Giving the contractor the benefit of the doubt and assuming his crew to be an exceptional one, that would make 40 batches an hour. A 1,000 lb. batch will lay 5 sq. yd. of 2-in. pavement, so the maximum output which could be allowed to a contractor doing his work properly and giving it the required time of mixing, would be 200 sq. yd. per hour.

In this particular case the work was prosecuted with a 9-hour plant day. That gives us 1,800 sq. yd. per day as the maximum output for that plant. We found on investigating the records that 2,500 or 2,800 sq. yd., and even as high as 3,000 sq. yd., had been laid per day, which meant that the mixing was cut fully in half. That accounted for the insufficient coating of the sand grains. That, combined with the lack of rolling and the low percentage of bitumen, accounted entirely and wholly for the failure of that pavement in 4 months. The traffic on that road was heavy. The foundation was of concrete 8 ins. thick and the subsoil was properly drained. There was no question of improper foundation or improper drainage.

Further investigations involving a pretty close approximation of the daily amounts laid and their relative service records after the 4 months showed, in those cases where it was possible to trace them, which was about 30 per cent of the time, that the pavement laid in the period from early morning up to 11 o'clock has given very good satisfaction. That illustrates as plainly as words can tell what took place after the engineer had paid his daily visit and the contractor felt himself freed from further supervision for the balance of the day.

An inspector at the plant would have verified the weights of the mixture. He would have verified the time allotted to mixing. He would not have permitted them to reduce it and the mixture sent to the street would have been of uniform bitumen content and his temperatures would have been properly maintained. The cost of that inspector at the plant weighed against the indirect cost to the city through the inconvenience to the public while taking up and replacing that pavement, and the cost of a new pavement which will fall directly on the contractor would have paid for ten inspectors at the plant ten times over.

Lack of Care in Mixing Sand Causes Trouble in Second Road.—Now let us visit the second road. In this road two sands were used: one a coarse sand, and one a fine sand. In the fine sand the particles were almost wholly composed of quartz. They were very sharp and had rough surfaces to which bitumen adhered well. The coarse sand was partly rounded, and if used by itself would not have made a stable mixture. It was, however, the only coarse sand available in that location at anything like a reasonable cost and not more than 33 per cent of it was required in the mixture. A mixture made according to these proportions would have had sufficient stability and was in all respects an excellent mixture. In this case daily samples were taken by the engineer on the street and the analysis that was made involved only the bitumen contents.

The contractor was a man who had very considerable experience in the laying of sheet asphalt, a man of high business honor and integrity and he tried honestly to lay the best pavement he knew how. The plant foreman was very good in some respects but slack in one particular. That one particular was fatal. Two years after that street was laid, possibly one-half of the pavement was in good condition and the balance was waving badly.

The cause for the defective portions of the pavement was clearly traced to lack of care in the mixing of the sands. The established proportion for the sands was two of fine to one of coarse. Now, if you have had experience with asphalt plants, especially at the start of a piece of work, you will realize how very difficult it is to get men to keep their coarse sand piles separate from the fine sand piles and establish a system whereby the sands will be mixed in the right proportion. In this particular case the coarse sand was very much cheaper than the fine.

The plant foreman, thinking to do his employer a good turn and reduce the cost to him of the pavement he was laying, tried to use all of the coarse sand possible. That policy was carried so far that possibly one-half of this pavement was laid with all coarse sand and no fine sand in it.

The analyses showed that the bitumen content of that pavement ran uniform. The men on the mixer did their duty, using the same amount of sand and the same amount of filler and they kept the mixture uniform in these respects and the engineer congratulated himself that this pavement was more uniform than the average and he expected the best results from it. When we have a pavement with a given bitumen content composed of a large aggregate we have one in which the surface is more thickly covered with bitumen than in a pavement of the same bitumen content which is composed of fine aggregate. In this particular case, when using the coarse sand alone, the mixture containing 10.5 per cent bitumen probably carried over 1 per cent excess of bitumen, which was further aggravated by the fact that the rounded grains had a comparatively smooth surface. The result was a pavement which markedly lacked stability and under heavy traffic it became wavy and shoved badly. In this case, the entire failure was due to not properly mixing the sands. An inspector at the plant who was competent and faithful would have kept an eye continually upon the men who were feeding the sand to the drum and would have seen that the coarse and fine sands were mixed in the proper proportion. Had he done so, that failure would not have occurred.

Poor Workmanship on Street Cause of Trouble.—In the case of the third highway, which again was a main trunk line route, it also had a 6 in. concrete foundation and a subgrade more than ordinarily well drained, and only one sand was used. An inspector was present at the plant who was in every way competent. The analyses were complete and showed a mixture with a variation that was well within the average limits of departure from the standards set by the specifications. In other words, the mixture was better than the average.

The portions of the road that were laid in the early part of the season showed at the end of two years a very decidedly wavy condition. Portions of the road which were laid toward the latter part of the season were as perfect at the end of two years, if not better than the day on which they were laid. Here was a case where the mixture was not at fault but what happened was this: In the early season the contractor had difficulty in getting a competent gang for the street. He had a poor roller man. He also had a four mile haul from the plant and the men who shoveled the material after it was dumped from the wagon were untrained and rakers and shovelers trampled upon the mixture while it was being spread.

Complaint was made to the engineer having charge of the work of that very condition, but it appeared to be somewhat of a hardship to the contractor to expect him at the very start of the season to have a gang that was well trained and would fall into their places as they should. So, for a period of 30 days, workmanship on the street was tolerated which was not in accordance with the best practice but which would, possibly in 50 out of 100 cases, have resulted in an entirely satisfactory pavement.

As is always the case, those portions of the street where the mixture had not been properly raked and fluffed up contained places where the density of the pavement was greater than those parts immediately adjacent thereto, and when the roller passed over them there was left a pavement which did not have the same density throughout. The compression exerted by a heavy truck is greatly in excess of that which can be obtained with a steam roller and the concentrated traffic on that particular road found those spots that were less dense than others and began to depress them, and under modern motor traffic a depression once started quickly grows and gives rise to other depressions until a series of waves is formed, with disastrous results which are familiar to us all.

Topeka Mix Requires Careful Weighing of Asphalt and Other Aggregates.—The three roads in question were paved with sheet asphalt with 1½ ins. of binder course and 1½ ins. of surface mixture. In a normal sheet asphalt mixture, a total variation of 1½ per cent from the standard bitumen content desired is not necessarily fatal to the road or even extremely detrimental so that with this type of pavement a certain amount of inaccuracy in weighing the ingredients can be tolerated without specially bad results but in a great many sections of this country they lay what has been called Topeka mix, which is more or less of a hybrid. It was originally a sheet asphalt mixture containing a small percentage of stone, small enough in quantity and size to avoid the Warren Brothers' patents. The Warren Brothers had really covered the best possible grading for a coarse mineral aggregate in a bituminous pavement. There was great objection to laying a patented pavement and in order to get around that, they tried to lay this pavement which had only a small amount of stone in it. A great deal of this kind of pavement has been laid.

Some of it has given very good results. In some cases its use has been justified by the fact that stone is cheaper than sand and the more stone the cheaper the aggregate will be and the less will be the amount of bitumen required, and, therefore, a considerable reduction in the cost of the pavement will be effected. The limit of variation in bitumen contents permissible in a Topeka mixture is, however, very much smaller than that which is permissible in a sheet asphalt mixture; therefore, more careful watching is required on the part of the platform mixing gang and greater accuracy in the weighing of the asphalt and the other ingredients of the batch.

When you think of men in a cloud of dust that at times is almost unbreathable, turning out 40 batches an hour all day long, one wonders that they do as good work as they do and it also becomes a matter of wonder how an engineer, having in charge a pavement involving 40 batches an hour separately weighed, could possibly go on without an adequate plant inspector and yet feel that the safety of the project was reasonably insured.

The Question of Temperature of the Mix.—There is another point which I would like to discuss with you, which was not involved in the case of these three roads mentioned, in order to illustrate another vital reason why an inspector should always be present at the bituminous mixing plant, and that is, the question of temperature. A test of the temperature of the mixture as it leaves the plant or as it reaches the street is not sufficient.

In making the mixture we have two elements which are heated, the mineral aggregate and the asphalt cement. If we overheat the mineral aggregate and have a cool asphalt cement we have in the finished product a mixture which will come within the requirements of temperature but we will have injured the mixture because the mineral particles carry only a very thin film of bitumen and if heated beyond the danger point this thin film of bitument will harden very rapidly. If, on the other hand, the sand or stone has been saturated with moisture by heavy rains, the capacity of the drum for drying and heating the mineral aggregate will be reduced. Under such conditions, a foreman anxious to turn out a large output is tempted to overheat his asphalt to offset the low temperature of his heated aggregate, thus increasing the amount of mixture of normal tempertaure delivered by the plant. Such a mixture will be defective owing to undue hardening of the asphalt in the kettles and the bond between the bitumen and the sand will probably be weak.

Need for Watching the Sand.—In many cases, sand, which forms 75 per cent or more of a sheet asphalt pavement, is obtained from large pits that are operated by experienced men and they deliver a uniform supply which requires very little inspection to insure the use of suitable sand in the mixture. In other cases, the contractor frequently opens up his own sand pit. Oftentimes stripping is required and the face of the sand pit is found stratified, fine and coarse. Sometimes it is necessary to discard a layer 2 or possibly 3 ft. deep at the top in order to get a proper grading for the mineral aggregate.

The contractor hires teamsters and places a man at the pit with a scraper and he instructs these teamsters to go to a certain portion of the pit and take the sand from there. The local teamster knows that the more loads he gets the better he will be paid and he takes the sand from the easiest or nearest part of the pit and the consequences are that half the loads should have been rejected. In other cases, where coarse and fine sand is mixed, it is very difficult to get the contractor to keep the sands separate.

The drivers are careless and dump fine sand on the coarse pile and vice versa and there is no possible way of separating and grading the sands properly and the consequence is that the mineral aggregate varies so much that it does not come within the limit of the specifications or good practice, and, even if it does happen to fall within those limits, the variation is still so great that in order to secure the best results, the bitumen content should be varied. This it is impossible to do satisfactorily.

The asphalt cement in former days used to be made at the plant by fluxing a hard asphalt with flux but today most of the large asphalt manufacturers send tank cars that are tested, either before they leave the plant or on delivery, and the variations in penetration are very trifling and do not require to be tested more than once per tank car delivery instead of once for every kettle filled at the plant unless the contents of the kettles are kept under heat for a very long time.

Drainage for Roads in Prairie Regions

Methods Employed in Province of Saskatchewan, Canada, Described in Paper Presented June 14, at 9th Annual Convention of Canadian Good Roads Association

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There are two distinct kinds of road drainage, surface drainage and sub-drainage. Surface drainage is the principal factor in the construction of roads in the prairie provinces. Transverse surface drainage is obtained by crowning the road, the height of crown varying somewhat with the different classes of soil. On roads being constructed in Saskatchewan under the provisions of the Canada Highways Act, the standard height of crown is 6 in. for 20 ft. road surface, or a slope of slightly more than 1-2 in. to the foot.

From the proceedings of previous conventions held by good roads associations, we find that a good many engineers recommend a crown slope of 1 in. to the foot, and on heavy clay soil a slope of even 1 1-2 in. to the foot has been recommended, but the writer is of the opinion that those who recommend a high crown on a heavy clay road, have had no opportunity of becoming intimately acquainted with the heavy gumbo soil found on the prairies. After a shower of rain lasting 20 to 30 minutes, it is practically impossible for anyone to drive a car on a road in the gumbo districts with a crown slope of 1 in. to the foot or over.

Disadvantages of High Crowned Roads.—Owing to the very slippery nature of gumbo when wet, a highly crowned road in this class of soil is impassable in wet weather, but how about its relative serviceability in dry weather? We have long dry periods in July, August and September on the Western plains. The heavy soil bakes hard, cracks and becomes broken into granular particles by traffic, and is thrown out of the wheel tracks by rapidly moving motor cars, with the result that deep ruts develop and the surface is so hard that it is impossible to repair the damage satisfactorily, until the surface is softened by rain.

On an excessively crowned road, the traffic is confined to the exact center of the road surface and consequently the development of deep ruts in dry periods is accentuated. If the road had a reasonably slight crown, traffic would be distributed over the road surface and the maintenance problem would be reduced. Another feature, is the safety of the traveling public. On a high crowned road, cars in passing are always liable to skid into the ditch and upset, even while traveling at moderate speed, whereas on a 20 ft. road with 6 in. crown, cars can pass in safety at any reasonable speed. Still another feature in connection with high crowned roads, is the severe wear and tear on tires. When ruts develop in the center of road, due to the concentration of traffic at this point, a new track is developed on either side of center line, forming two definite lines of traffic, and on both of these the rear wheels of motor cars are constantly skidding down the slope, making the driving of a car difficult, dangerous and expensive.

A high crown has the serious disadvantage outlined above, and furthermore, is not required for adequate surface drainage. Water will be discharged just as well from a slope of ½ in. to the foot as from a slope of 1 in. to the foot, providing the road surface is kept free from ruts by proper maintenance, and grass and weeds are not allowed to grow on the shoulders of the road. When, after a rain, the water has all been carried away and the surface of the road remains smooth with no signs of erosion, the crown slope may be taken as being satisfactory. In the case of excessive slope of crown, small rivulets will appear caused by the too rapid discharge of water.

On steep grades the crown of a road should be increased slightly so as to minimize the danger of water running down the road surface in a longitudinal direction, an application of sand or gravel being required to prevent skidding in the case of heavy clay soils.

Drainage on Side Hill Roads.—The transverse drainage of side hill roads in Saskatchewan is very often accomplished by having the entire road surface inclined towards the ditch at a slope of ½ to ¾ in. per foot of width. This method results in more water being on the road for a longer period than in the case of an embankment where the slope is from the center towards the side, and also causes a greater volume of water in the ditch with relatively greater erosion resulting. This type of cross-section is used on the provincial highways of Saskatchewan only on sharp curves and heavy side hill cuts where the slope of road-bed towards the hill adds somewhat to the safety of the route. On comparatively straight side hill grades where the transverse slope of hill does not exceed 20 per cent, part of the surface water can be advantageously discharged over the embankment by the crowning of the road surface.

The second stage of surface drainage is the conveying of water discharged from road surface to a natural water course, or to a large slough or lake where the additional volume of water will not cause damage to public or private improvements. The transverse drainage of road surface can be perfectly obtained, but longitudinal drainage is often a very difficult problem in connection with highway construction. To provide ideal surface drainage we require that the side ditches, culverts, bridges and outlets constitute a system capable of draining completely the water from rain and spring thaws as quickly as possible but without erosion. The small number of natural drainage channels, and the uniformity of elevation on the prairie sections of our mid-western province makes longitudinal drainage unusually difficult; also, the absence of trees and shrubs on prairie sections increases the rate at which surface water is discharged, and also increases the amount of the discharge, as compared with treed areas. These conditions, combined with the large catchment basins of our natural water courses, cause extremely severe flood conditions, which make necessary special provision for adequate water way.

Side Ditches and Offtakes.—Judging from an examination of a large mileage of road, constructed under the supervision of local municipal authorities in the Province of Saskatchewan, it is evident that in a great many cases it was considered that when the road surface was given a very high crown, adequate provision for drainage had been made. The side ditches are often constructed purely for the purpose of securing material for the crown, and the result is elongated ponds, not drainage ditches. This is a very serious mistake, and the emphasis is being put in the wrong place, for the drainage of the right-of-way is of far greater importance than the transverse drainage of road surface. Such sections of road are invariably rutted, unless the embankment is 3 or 4 ft. above water level, whereas under similar conditions of soil and rainfall, the balance of the road is in first class condition.

It is expensive and usually unnecessary to provide long sections of side ditches at a uniform gradient. Most of Saskatchewan is sufficiently rolling that continuous drainage can be provided from each summit to the nearest culvert without any serious difficulty. The gradient on these ditches is not necessarily uniform. On our provincial highways we endeavor to provide for the removal of all water from the side ditches and borrow-pits. We also endeavor to drain, or at least lower, the water level in sloughs which are on the right of way. If the depth of water in the slough exceeds 2 ft. and extends for a considerable distance, and cannot readily be drained, we usually divert the road so as to avoid the slough, having in mind the high maintenance charges on a road constructed through a body of water.

The side ditches on roads improved by the Department of Highways are so designed that they can be constructed and maintained by standard road building and road maintenance machinery. The standard depth of side ditches is 18 in. on our provincial highways. In the case of turnpike sections of road the inside slope of ditch is 4 to 1 and the outside slope 1½ to 1. In the case of a roadway in excavation, the inside slope of the ditch is increased to 3 to 1 in order to reduce the volume of excavation by reducing the out to out width of roadway, maintaining the same depth of ditch and crown width.

In the case of a roadway constructed around the base of a hill, it often occurs that the roadway could be built at the same elevation for a considerable distance, but as there must be a slope to the side ditch, we construct the road to a slight gradient so that the ditches may be of uniform depth. If a level stretch of roadway were constructed the ditches would be shallow at the center of the level stretch and too deep at the outlet. In the case of all excavations we provide for a slight gradient to roadway so as to facilite drainage.

Offtake ditches are provided when there is not a sufficiently well defined water course to carry away the water discharged from any culvert. When the distance from the summit to culvert is only 2 or 3 stations we find that the surface water can be satisfactorily disposed by by digging a ditch from culvert outlet to the edge of the right-of-way and discharging the water into the adjoining field—well tilled soil will absorb this quantity of water without damage and if the land is not cultivated, no objection is usually made to this method by the owner of the property. At every point where water is carried through a culvert under the roadway, we endeavor, if possible, to discharge this water from the right-of-way directly opposite the culvert.

Trouble from Drifting Soil Filling Ditches.—We have a difficulty in connection with surface drainage which is unknown in other portions of Canada. That is, the almost annual obliteration of road ditches by drifting soil in prairie areas where the soil is heavy. We have severe wind storms during March and April which cause the clay soils pulverized by intensive cultivation, to drift like snow. In a great many cases, turnpiked roads are not only obliterated, but are rendered very difficult to rebuild, owing to the granular nature of the drifted soil which, by the way, is often mistaken for sand. This granular material is very difficult to handle with a blade grader, as it runs around or over the blade, and the clearing of the ditches is a real problem. When you have succeeded in removing the drifted material from the ditches to the crown of the road, you have also succeeded in rendering the road impassable, as this material cannot be consolidated except when wet.

Two years ago, a ditch approximately 1,000 ft. long and 2 to 3 ft. deep, was constructed to drain a slough which was situated on the right-of-way of one of our trunk roads. This ditch was completely filled by drifting soil the following spring, but on account of the granular nature of the material, the ditch continued to be effective for one season, but ditches required to carry running water are immediately rendered useless when filled with this material. To maintain many of our roads we will have to build protection fences, similar to snow fences, to prevent the drifting soil from filling the ditches, unless the agriculturists devise a system of crop rotation which will provide sufficient fibre in the soil to prevent this drifting action.

Culverts.—Culverts form a part of a surface drainage system, and the following are the types of culverts installed on roads being improved by the Provincial Department of Highways:

(1) Pipe culverts, (a) corrugated iron; (b) concrete.
(2) Box culverts, (a) concrete, (b) timber.
(3) Arch culverts of concrete.

On our trunk roads we do not use timber culverts, except in special circumstances. We believe that culverts of a permanent type should be used exclusively on main roads and we are able to adhere to this policy excepting where we find it necessary to provide large openings to carry off the spring floods.

Our river valleys are deep and vary in width from ¼ mile to 4 miles. Very often the entire valley is flooded in the spring, and we have to construct embankments of from 3 to 5 ft. in height across the flats tributary to the river. To protect these embankments against spring floods we have to provide culverts having 16 to 20 ft. clear spans at the several points where channels develop when the river is in flood. The cost of constructing 3 or 4 permanent culverts of these dimensions, possible in one mile of road, is almost prohibitive, in view of the amount of funds available, consequently under these circumstances we have to resort to pile bent culverts.

In connection with the use of pipe culverts, we find when these culverts are placed sufficiently low to remove all water from the side ditches, they are quite useless during the spring run off, unless the snow and ice has been removed from the culverts by a maintenance patrol. Alternative thawing and freezing during the month of March often fills the culverts with ice, which is very difficult to remove, and consequently we find it necessary to use box culverts with a considerable vertical opening at points where there are natural water courses. At smaller runways we often place a culvert at natural surface elevation to take care of spring run-off. When installing a pipe culvert as an evener in an embankment constructed across a slough, we place the culvert on solid ground near the end of the embankment, at an elevation equal to the normal water level in the slough. The average cost of culverts varying from 12 in. to 36 in. diameter per mile of road is approximately $400.

Sub-Drainage.—We are unable to build hard-surfaced road in the rural parts of our province, consequently we do not provide under drainage on our roads except in so far as side ditches remove water from the roadbed if they have a proper gradient and an outlet, or provide a source of water to be carried through the subgrade to the road surface by capillary action if water remains in the side ditches for any length of time.

We occasionally find it necessary to provide under drainage in a cut where the earth formation is such that water continues to seep out of the hill to the roadway, the method adopted being a rock filled ditch, but tile underdrainage on earth roads in our province, where the average cost per mile of roadway does not exceed $2,000 is not to be considered. Even if the necessary funds were available, the writer questions the serviceability of a tile drain at a depth of 2 or 3 ft. in a heavy gumbo soil which will retain water in undrained side ditches for a perod of 2 to 3 weeks until it disappears by the process of evaporation.

We adopt the principle of under-drainage by endeavoring as far as possible to keep our roads on the natural surface, and avoiding deep cuts. The surface soil is more porous and has a great many passages made by worms and insects, decaying roots, etc., consequently a road on surface soil has considerable sub-drainage already provided, also evaporation is much more effective on the surface than in a cut.

Our experience in connection with sub-drainage is so limited that the writer will not attempt to discuss the matter further, but we are fully aware of the fact that the fundamental basis of all road maintenance is drainage, and we are endeavoring in the face of unusual difficulties to provide proper and adequate ditches and culverts on our provincial highways system, so that with careful attention our earth roads, the only roads we can at present afford to build, shall render to the taxpayers of our province the maximum service of which they are capable.

Methods of Maintaining Macadam in Ontario

Practice of Toronto and York Roads Commission Described in Paper Read March 2, Before Ontario Good Roads Association

By E. A. JAMES,

Chief Engineer of the Commission.

Stone roads may be divided into two classes: (a) Stone roads bound by traffic; (b) stone roads water bound.

While the writer does not advocate the construction of roads of the former type, yet we find that many miles are still being built, and with a medium hard stone and iron tired traffic, it is surprising how quickly they bind and rebind. Their maintenance, however, must necessarily be somewhat haphazard, as one cannot estimate just how they will act under traffic. Holes should be filled with 1-in. stone, sprinkled with limestone dust or loam. The sides of the road should be kept well shaped so that water will run quickly to the ditches. Oiling may be adopted similarly, and similar methods to those used on water bound macadam. We are, however, dismissing the maintenance of this type of road with a few words. Firstly, because this type is not economical either in construction or maintenance, and secondly because the remarks on the maintenance of the second type may be applied, with slight modification, to the maintenance of roads of the first type.

Maintenance Organizations.—In maintaining roads, two type of organization have been adopted, namely "patrol" and "gang." Both systems have merit, but in our experience the gang system has given better results.

In the patrol system, one man or at most two men, have a small mileage to look after, and we have found it very difficult to secure a man who is a good workman and of the temperament that makes it possible for him to work steadily day after day alone, patching and cleaning up along the roadside. Although he works conscientiously, we find that without someone with whom he can compete he becomes slower and slower, until although he is busy all day he only does from one-half to three-quarters of the work a man should do.

By adopting the gang system, we find that by using very light motor trucks we can give a foreman 20 to 25 miles of road, and from four to five men. Under this system we can secure foremen of greater ability and with more initiative, and there is companionship and rivalry among a man and his gang and between gangs, which tends both for efficiency and economy.

On stone roads well built, there are several months in a year when little or no maintenance is necessary and the gang can be used to construct small culverts, do light grading or build short stretches of improved road. In this way the foreman and his men maintain their interest in road work, and we have found that the men who have had experience in road building are, without exception, the best men to employ on road maintenance.

Maintenance During First Year.—The maintenance for the first few weeks after a stone road has been completed, consists of seeing that the limestone film is worn uniformly without removing the filler between the stones. In other words, endeavor to get the traffic to distribute itself over the full width of the pavement.

With the first indications of ravelling, oiling should be commenced. This first oiling consists of spraying with a light asphaltic oil, say 40 per cent bitumen, applying approximately ⅓ gal. per square yard, and then sanding the applied oil.

During the first season only light oils should be used on stone roads, otherwise there is danger in forming cakes on top of the limestone film, which break and cause the road to pit. Such a stone road, oiled in this manner, will take legal traffic up to 75 motor cars and 100 horse-drawn vehicles per hour.

The second step in this maintenance will occur the following spring, when a few holes may develop, due to the unequal rolling or stones of unequal size being used. These holes should be cleaned out, the loose stone removed, and the hole patched with 1¼-in. stone, bound in place by bitumen poured hot, using approximately 14 gal. of bitumen per cubic yard of stone. It is well not to use too much bitumen, nor to fill the hole too full, otherwise there is a tendency to shove. The patch should be pounded with a hand pounder.

The second method of patching is to use K.P., which is a bitumen that may be mixed with the stone cold, and the mixture thus formed tamped into the hole that has been properly cleaned and shaped. In this case it is better to use a mixture of ½-in. and ¾-in. stone, thus producing a dense aggregate.

Maintenance During Second Year.—During the second year, it will always be found a good investment to treat with bitumen the water bound macadam road, and whether it is done before or after the patching is immaterial. It will usually be found, however, that to get the best from carpet surfacing the road should be treated early in the season, before there is time for patching, but this does not spoil the patch work, as the bitumen penetrating the road assists in binding in the patches, whereas if great care is not used in spraying, bitumen applied on top of the patches cuts back the binder in the patches causing them to shove. The second year treatment should be preceded by careful sweeping to see that all dust, dirt and film has been removed. This may be done with the aid of hand brooms, or by using horse-drawn revolving brooms. Care must be taken, however, not to sweep so vigiroously as to disturb the stone.

The weight of the character and intensity of the traffic, but a tar having the consistency of Tarvia "B" or a 65 per cent asphalt sprayed evenly and hot; ⅓ gal. to the yard and 30 lb. of ½-in. chips or pea gravel per square yard, will mat into a wearing surface that will carry the traffic of our leading highways, 400 motor cars and 75 horse-drawn vehicles per hour. In the fall the necessary patch work should again be carried out, when it will be found that the carpet coat has ironed out into a perfect mat.

Third Season's Work.—The third season, patching in the Spring as before will be required, but the carpet coat can be reduced to 1/6 gal. of bitumen per square yard, and the stone to 10 lb. per square yard.

Thin repairs may be made by spraying from a watering can hot bitumen, and sprinkling with ½-in. chips or pea gravel. Where the road is covered with a mat of bitumen, this surface patching is very advantageous, as it prevents holes developing.

How Iowa Levies Assessments for Surfacing Country Roads*

By F. W. PARROTT,
Auditor, Iowa State Highway Commission.

General Principles.—The principle involved in determining road assessments on either primary or secondary roads is not different from that involved in levying assessments for other improvements, the cost of which is borne in whole or in part from special assessments. For years the cost of paving in cities and towns has been assessed to abutting or adjacent property and the cost of draining farm lands to the lands directly benefited.

In considering the benefits derived from the paving of country highways, the relative benefits may be placed in three general classes:

(1) Benefits to those in the immediate vicinity of the improvement.

(2) Benefit to the community adjacent to the improvement.

(3) Benefit to the general public, the state and the nation.

The benefits apply in the greatest degree to those in class one, and in a somewhat lesser degree to those in class two. Hence the justification for the assessment of one-fourth of the cost to the property within a certain zone.

Primary Road Assessments.—The law enacted by the General Assembly provides for assessing benefited property for one-fourth of the cost of hard surfacing primary roads and for one-fourth the cost of hard surfacing, graveling, oiling or otherwise surfacing secondary roads. In considering the general principles involved in determining such assessments and the legal machinery set up for their collection, let us first consider the levying of assessments on the primary road system. In considering assessments on secondary roads we will then need to consider only those provisions which differ from those in connection with primary roads.

Application by Board of Supervisors.—The primary road law provides that when the board of supervisors makes application to the highway commission for the improvement of a division of the primary road system by hard surfacing, such application shall be accompanied by a plat of a proposed assessment district. Each district shall be clearly designated by some appropriate name and number. Portions of primary roads which diverge from a common point may be included in one district. No district shall embrace real estate within a city. All real estate lying upon and immediately adjacent to each side of the highway and constituting two continuous zones each one mile in width, measured from the center of the highway, shall be included within each district. The board of supervisors may increase the width of said zones to not exceed 1½ miles. The outer boundary of such increase may follow governmental or other well defined lines, and if any part of a governmental forty acre tract or less is within 1½ miles of the center of the road then the entire forty acres or less may be included within the district. Should the center of the highway be less than 1½ miles from an interstate boundary line, then the zone adjacent to such line may extend to such line. Should travel to or from such highway to real estate within either of said zones be wholly barred by a natural or artificial barrier, the board of supervisors may wholly exclude such real estate or any portion thereof, or may make a nominal assessment thereon.

Should the board of apportionment find that certain tracts have been omitted that ought to bear an equitable portion of the expense of the improvement and which are within 1½ miles of the improvement and not embraced within any other district, they shall submit a separate report showing the recommended assessment on such omitted property.

In case an original assessment is found to be insufficient an additional assessment may be made in the same relative ratio as the original assessment.

The plat of the proposed assessment district should be on a uniform scale and prepared on sheets about the size of a standard road profile sheet. The title page should refer to the name and number of the district in the same language as is used in the resolution passed by the board of supervisors in establishing the district. The title page should show a layout of the entire district and show references to the attached sheets representing the detailed plat of the district.

Approval by State Highway Commission.—The primary road law provides that the highway commission shall examine the project and before approval shall have power to modify it, and that upon the approval by the highway commission the district shall be deemed finally established, whereupon the board of supervisors shall cause to be entered and published in the minutes of its proceedings a description of all real estate embraced within said district. The notice herein provided for through the publication of the proceedings of the board of supervisors is the first notice in reference to the establishment of the assessment district provided for by law.

Board of Apportionment.—The road law provides that a board of three resident freeholders of the county shall be appointed by the board of supervisors to apportion all special benefits to real estate within each district. No person shall serve on such board if he lives or owns real estate within the district. Whenever the total expense of such improvement within said district has been approximately determined, said board of apportionment shall with all reasonable dispatch personally inspect and classify in some uniform manner and under some intelligent description, and in a graded scale of benefits, all real estate within said district. It is suggested that the time of making the assessments should depend on the progress of the work. Said classification when finally established shall remain as a basis for all future assessments to cover deficiency, if any, unless the board of supervisors shall authorize a revision thereof.

Portion of Cost to Be Assessed.—The board of apportionment shall apportion 25 per cent of the total cost of the hard surfacing; sums expended for draining, grading, bridging and culverting shall not be computed as a part of the cost except that the cost of such draining and grading as is purely incidental to the construction of said hard surfacing may be included in the cost thereof. Cost of engineering on hard surfacing may legitimately be included in the assessment. No real estate under any circumstances, though embraced within more than one road assessment district, shall be assessed for the original cost of hard surfacing in an amount exceeding in the aggregate 4 per cent of the fair market value thereof. Any deficiency in the said 25 per cent of the total cost occurring by reason of said 4 per cent limitation shall be paid from the county's allotment of the primary road fund. The interpretation commonly given this 4 per cent limitation is that no part of the deficiency arising from said limitation can be assessed to other lands in the district. In establishing the boundaries of a proposed district the board of supervisors should include as small a relative amount of low priced lands as is possible. Real estate owned by the state or any county shall be assessed as other real estate, but no other publicly owned real estate shall be assessed. In apportioning benefits to real estate owned by the county or state no consideration shall be given to buildings thereon.

Real estate located in towns of less than 2,000 population may be included in assessment districts and assessed in the same manner as other lands. Hard surfacing in such towns is limited to continuations of the primary road system and in towns the maximum width of paving, the cost of which may be paid from the primary road fund, is 18 ft.

The board of supervisors shall not drain, grade or hard surface any highway within the limits of cities.

There has been a great deal of speculation regarding the assessment of railroad property lying within assessment zones. Most boards of apportionment have not so far made any assessments on railroad right-of-way and, so far as I know, no railroad has paid an assessment for paving under the primary road law.

Form of Report.—The apportionment report shall specify each tract of real estate by some intelligent description, the amount apportioned thereto, and the ownership thereof as the same appears on the transfer books in the county auditor's office. It shall be filed with the county auditor.

Basis of Assessments.—The law contains no definite instructions to the board of apportionment as to how they shall arrive at a fair distribution of the cost. No instructions have been issued by the highway commission as to how assessments shall be made. Each board of apportionment has been allowed to adopt, in so far as the highway commission is concerned, whatever system in its estimation was most practical. The law simply states that among other relevant and material matters, if any, due consideration shall be given to the fair market value, the relative location and productivity and to the relative proximity and accessibility to the improvement.

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*From the 1921 Proceedings of the Iowa Engineering Society.

The best system which has come to my attention is that outlined by the auditor of Scott county. He suggests that each of the above named feaures be given an arbitrary value. One of the tables of values suggested was:

Proximity	50
Accessibility	20
Value	15
Productivity	10
Location	5
Total	100

Let us first consider why these conditions should be given weight in determining benefits.

A farm or lot fronting the paved highway receives the greatest benefit and no difficulty is encountered in classifying lands as to proximity. Unquestionably, proximity should have a high value.

The question of accessibility depends upon the layout of the farm and the means of obtaining access to the improved highway. The improved highway may be more easily accessible to a farm some distance from the improvement than to one which lies nearer.

In considering location it is apparent that the paving is a great benefit to the land if the paving leads to a market, while if the market is at some point beyond the farthest end of the paving, the said paving cannot be said to be of material benefit from the standpoint of facilitating the marketing of products.

The fair market value of the land is an important factor. A tract of land may be of little value as farm land but may be of considerable value as resident property. This condition will be met in districts adjoining cities and towns, and most of the improvements first undertaken lead out from cities and towns.

Productivity is a factor in fixing market values, but in addition thereto the productive land is more responsible for the need of paved roads than unproductive land as it causes more traffic over the road.

Let us take the values above given and apply them to a 40-acre tract as follows:

	Maximum value.	Relative value this tract.
Proximity	50	30
Accessibility	20	10
Value	15	12
Productivity	10	10
Location	5	2
Total	100	64

The total number of points per acre is 64 and since the tract contains 40 acres the total number of points value given to said tract would be 64 × 40, which equals 2,560. Carrying out this system of valuing each feature which enters into the determination of the assessment we would arrive at the number of points value to be given each tract included in the district. The total number of points for all lands in the district would then be divided into the total amount of the assessment and the value of each point determined. Applying this value to the number of points assessed against each tract we would arrive at the assessment for each tract of land. This system is based on the same principle followed in determining drainage assessments though the application of the principle is made in a somewhat different form.

Hearing.—Upon receipt of the report of the board of apportionment, the county auditor shall fix a day for hearing before the board of supervisors. Notice of hearing shall be given by publication and by personal service on each owner.

All interested parties shall have the right to file objections on or before the date of hearing. The board of supervisors shall hear all objections and may increase, diminish, annul or affirm the apportionment of any part thereof.

Any land owner may appeal to the district court from the order of the board of supervisors by filing with the county auditor within fifteen days a bond conditioned to pay all costs in case the appeal is not sustained.

Payment of Assessments.—On final determination the said assessment and all installments thereof shall be then due and payable and shall bear interest at 6 per cent per annum from said date. If any owner than the state or county shall within 20 days sign a waiver he shall have the right to pay said assessment in ten installments. The whole assessment shall draw interest at 6 per cent from the date of levy. Installments shall mature and be payable at the same time and in the same manner as the March payment of ordinary taxes. Where no waiver is signed the whole assessment shall mature at one time and be due and payable with interest from the date of levy, and shall be collected at the next succeeding March semi-annual payment of ordinary taxes. All delinquent payments shall be subject to the same penalties and be attended by the same rights and remedies for collection as ordinary taxes.

An owner who has availed himself of the ten-year option may at any time discharge his assessment by paying the balance then due with interest on the entire amount for thirty days in advance.

Certificates—Sale—Tendered to Contractor.—To provide funds to pay the cost of the improvement the board may issue road certificates in the name of the county in an aggregate amount not exceeding the unpaid amount of special assessments. The county treasurer may sell said certificates for not less than par and accrued interest and apply the proceeds in the payment of the cost construction, or he may tender such certificates to the contractor in payment for the work performed.

Legality of Proceedings.—It is essential that the law be carefully complied with and that a full record be made in reference to the levying of assessments and the issuing of certificates in order that the county or the contractor may be able to market these certificates, as all proceedings are carefully examined by attorneys employed by the purchaser.

Joint Districts.—Joint districts may be established:

1. When primary road is not more than one mile from county line.
2. When a primary road approaches a county line at such an angle that the hard surfacing will reasonably necessitate a district with a substantial part thereof in different counties.
3. When a primary road constitutes a common boundary line between counties.

In case of common boundary line roads the boards may jointly agree as to which county shall construct said improvement. Should the boards be unable to agree as to any of the matters affecting the construction the project or as to which county shall be the constructing county, the question shall be determined by the highway commission. Under the provisions of the law the board of supervisors and the county auditor of the constructing county shall have full jurisdiction over the entire district.

Improvements on Corporation Lines.—Whenever any public highway that is a part of the primary road system is located along the corporate line of any city, it may be improved by hard surfacing by the board of supervisors as part of the primary system under this act. In such case, one-half the cost of such hard surfacing along said corporate line shall be paid by such city, and the board of supervisors of the county and the city council of such city are hereby authorized to agree in writing for the payment by the city of one-half the cost of such improvement, and in case they cannot agree upon the amount to be paid by the city, and date when payment is to be made, the matter shall be referred to the state highway commission, whose decision shall be final. Said city may pay said amount from its general fund, or it may proceed under Sections 840-h to 840-r, both inclusive, Supplemental Supplement to the Code, 1915, for the assessment and collection of such cost, or it may pay in the first instance from such general fund and reimburse said fund thereafter from proceeds realized from such assessment proceeding. The city in such case, for prompt realization of funds, shall have the right to issue road certificates in anticipation of taxes and assessments to be realized from such assessment proceeding under Section 840-h to 840-r, Supplemental Supplement to the Code, 1915.

Secondary Roads—Points of Difference.—On secondary roads assessments may be made for the cost of improving or graveling, oiling or otherwise suitably surfacing. The board of supervisors shall have power to establish secondary road districts upon petition signed by not less than 20 per cent of owners residing within the county. The boundaries of the district need not conform to the provisions as to the fixing of boundary lines on primary road districts. The petition shall describe the lands which are to be included in the district and shall state the type of improvement which is contemplated.

The apportionment of Cost is as follows:

	Per cent.
(a) County road:	
1. County road cash fund	75
2. Special assessments	25
(b) Township road:	
1. County road cash fund	25
2. Township funds	50
3. Special assessments	25
(c) Levying of special assessmentns same as primary roads.	

Experiences at Ottawa with Refined Tar in Road Construction*

By A. F. MACALLUM,
Commissioner of Works, Ottawa.

The success of simple surface treatments on waterbound macadam in resisting modern traffic has led to a reversion to the macadam type to meet the needs of roads of comparatively light traffic. The refined tars for cold application have good penetrating power which makes them valuable in treating bituminous macadam of every type. In the city of Ottawa we have 30 miles of road treated with refined tar. Seventeen miles are on the Ottawa Improvement Commission's highway and 13 are on residential streets in different parts of the city. The Improvements Commission, appointed by the Dominion Government, supervises the construction and maintenance of the roadways throughout the chain of parks. About 90 per cent of this traffic is motor, the remainder being carriage, so that while there is comparatively heavy traffic, there are very few heavy loaded vehicles with steel tires, except on some short sections.

The point where it becomes desirable from an economic standpoint to build a bituminous macadam instead of a plain macadam with a surface treatment is not easy to determine, although theoretically, the decision would rest on the ability of the road to resist internal water. A surface coating will protect the tops if kept intact but will not prevent wear within the road itself. If the loads on a macadam road increase beyond the ability of the structural strength of the road to bear them, the stones move on each other and internal disintegration takes place.

When to Make Use of Bituminous Material.—If the stone used on the road happens to be soft and carrying heavy loaded vehicles the road will quickly wear out from within, even though the surface is protected by treatment. Any approach then to the point where this wear becomes a serious menace to the life of a road should indicate the advisability of introducing a bitumen into the structure of the road to prevent internal wear. On the Ottawa Improvement Commission highways mentioned above, with the nature of the traffic indicated, it has been found that a surface treatment was sufficient as the stone used was comparatively hard, but where heavy loaded vehicles operated results were not so satisfactory. Two methods have been adopted in introducing the road tar: by mixing in a machine somewhat like asphalt or by penetration by pouring the refined tar directly on the road metal. The mixed method is only used when a somewhat higher type of road is intended, but as the penetration method is less expensive and easier to handle with less expert workmen, it is the method generally used.

The foundation for a tar macadam should be carefully prepared, drained either by side or under drains, and sometimes by both, according to the conditions met with and as this applies to all road construction it will not be considered further, except to mention that the rolled subgrade should have the cross-section of the finished surface. This crown should, however, be not greater than ⅜ in. to the foot.

Construction Features of the Tar Macadam.—Assuming a new roadway, there are two courses, the lower or base varying from 4 to 8 in. according to the nature of the foundation. The stone used is generally specified to pass a 3½-in. ring and remain on a 2¼-in. ring and this stone is spread evenly over the subgrade and rolled. This stone, if laid in greater layers than 4 in., will not compact properly under a road roller of 10 to 12 tons and if a thicker course is required it should be rolled in layers. Unless grade stakes are set and the rolling worked from the sides to the center it is rather difficult to get a correct contour to the surface. After this base is solid, the voids between the stones should be filled with clean gravel, sand, or stone screenings. This filling tightens up the base and prevents the refined tar from the upper course from running down into the base and draining away from where it is needed. After rolling, this base is ready for the upper or tarred course and this base should be 2½ in. below the proposed finished surface of the road.

Tar Treatment of Old Macadam Roads.—Where old macadam roads are to be treated the old surface is scarified, new stone added where necessary and rolled to the same grade, namely, 2½ in. below the surface. The top or wearing course is now spread uniformly and unless this is done carefully there is the possibility of uneven wear. The stone for this course is usually from 1¼ in. to 2¼ in., the hardest stone if procurable being of the smaller size. It is very essential that this stone shall be clean and as free as possible from dust, clay or loam so that a good penetration may be secured. The stone must be carefully rolled to secure a firmly knit surface but should not be over-rolled or have the angular points of the stone crushed off and thus prevent the refined tar penetrating to the first course. This course which is spread about 3 in. deep will be compacted to a thickness of about 2½ in.

The refined tar heated in the tank cars to a temperature of from 200° F. to 250° F. is carried in tank wagons and poured evenly over this wearing course which will require about 1½ gal. per square yard. To apply this uniformly requires experience which, however, an intelligent workman can acquire in a few days.

On small jobs, where it is difficult to operate tank cars and wagons, the refined tar is shipped in barrels, heated in open kettles and hand pouring pots are used to distribute the tar. After the tar has been poured the surface should have a uniform black appearance, with the upper spaces between the stones showing. These upper spaces are now filled up with ¾-in. stone spread uniformly over the surface but not in enough quantity to form a distinct layer. The surface is again rolled to force the stone into the voids and any excess of small stones should be swept off with push brooms so that the seal coat will adhere properly.

The seal coat, usually about ½ gal. to the square yard, is now put on uniformly in a manner similar to the previous coat and a coat of screenings or stone the size of peas is spread evenly and rolled after which the road is ready for traffic.

Maintenance of Refined Tar Pavements.—So long as the surface is intact these pavements are very resistant to traffic but where the surface is broken the break spreads very quickly so that where a break occurs, repairs should be made quickly. Any road without maintenance is sooner or later of little value to a community and an improved road soon drops back into the unimproved class if it is neglected. Some types of roads last longer than other types without attention, but they are not for that reason always the most desirable and it is just as well to remember that there is no such thing as a permanent road.

As a rule, a community gets the greatest economic value out of a large mileage of reasonable-cost roads that can be cheaply maintained rather than out of a short mileage of high-cost roads of the heavy city street type, providing these cheaper roads are built up to the traffic they have to carry.

In Cambridge, Mass., previous to 1915 the cost of the upkeep on refined tar pavements averaged 2 ct. per square yard. In Ottawa the cost per square yard was 3 ct. for the last year. In the eastern states, on roads having the usual state road travel between towns I find that one road down for two years cost $12.50 per mile, another down five years, $67.10 per mile and two roads down for six years cost $184 and $258 per mile, respectively, all of these roads being about 20 ft. in width. From this it may be assumed that if necessary repairs are made at once and surface treatments applied when the wear of the pavement indicates their necessity, the cost will be very moderate. The secret of low cost then in repairs and maintenance is to keep the surface intact at all times.

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[*] Abstract of a paper presented before the Canadian Good Roads Association.

Group Life Insurance Plan Adopted by Large Company

Late in August the John A. Roebling's Sons Co., announced that all employes who had been with them a year or longer, on Sept. 1, 1922, would be protected by Group Life Insurance and Pension Plans. By arrangements with The Equitable Life Assurance Society of the United States, the insurance went into force automatically on midnight of Aug. 31.

The insurance is graded according to length of service, all employes more than one year and less than two years with the company to receive $500, increasing $100 each additional year of service until the maximum of $1,500 is reached for eleven years of service and over.

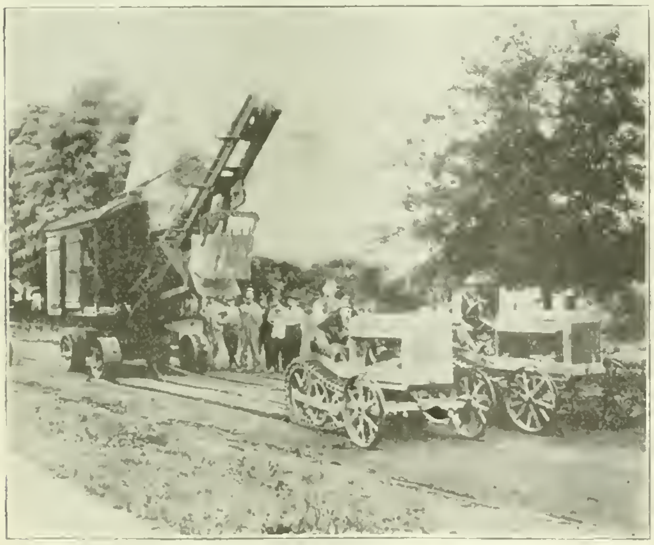
The Pension Plan contemplates retirement at age 60 for males and 55 for females, and in the event that this class of employe has served twenty years or more, they may request a pension or be retired at the discretion of the company. Any employe, however, who has served thirty years or more, or any male employe 55 years of age and female employe 50 years of age whose term of service is twenty-five years or more, may at the discretion of the company be retired from active service and granted a pension.

The amount of pension is determined by multiplying 1 per cent of the average annual pay during the ten years preceding retirement by each year of service. A minimum of $25 per month and a maximum of $250 a month has been established and will apply, except in cases where the pension is being paid in cases of total disability above referred to, where the minimum may be less than $25 per month.

By this plan there is assured a degree of protection of all employes and their families, thereby relieving them of a certain amount of worry, and at the same time building up a friendly spirit of co-operation essential for successful industrial life.

Speedy and Economical Moving from One Job to Another

The interesting picture below shows equipment of Peters & Baird of Wadsworth, O., just arrived on a new job at the end of an 8-mile trip over country and city roads. Their equipment, including a 22-ton steam shovel and other machinery, made the above trip in ½ day's time, all of the hauling being done by the pair of tractors shown in the picture. These machines are "Steel Mules" made by the Bates Machine & Tractor Co., Joliet, Ill., and were in use for both hauling and grading throughout the construction jobs.



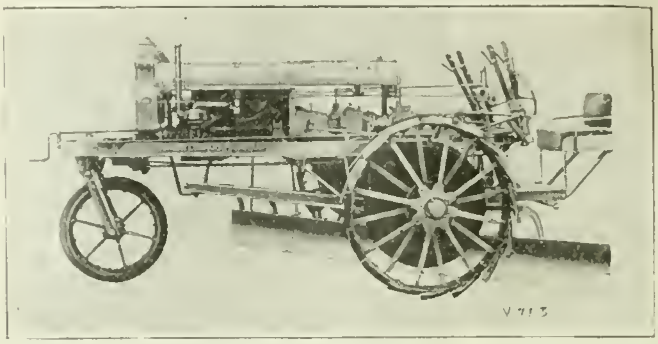
A Modern Mule Team and Its Load.

Improvements in the "Road-Razer"

The introduction of a power-lift for the blade, together with several other somewhat radical changes, made by the Avery Company of Peoria, Ill., in its one-man grader, known as the "Road Razer," have substantially improved the operation and convenience of that machine.

In the new model a power lift device connected with the motor and transmission enables the operator to raise or lower the blades instantly by merely tripping a lever. The blades are also arranged so that the angularity is changeable for instance, the angularity can be changed from a position required for maintenance work to a position of greater angle for doing such work as moving dirt after a grader, removing snow, etc.

All of the gears are entirely enclosed and run in oil. The machine is also roller and ball bearing equipped throughout. It has an improved ball bearing turntable on the front wheel, with two sets of solid steel balls running in oil. It has a removable flange, and also a friction brake on the front wheel. It is provided with a platform and comfortable cushion seat and back rest for the operator. It has a fuel tank holding 20 gal., the tank and hood being separate. It is equipped with an improved type of muffler, tool box, drawbar attachment for pulling wagons, oil tanks, cement mixers, etc.



One-Man, Power-Lift "Road-Razer."

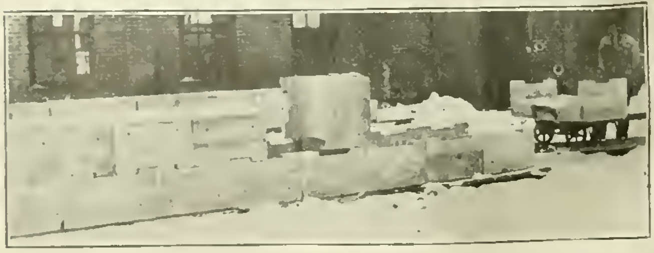
Interlocking Concrete Culvert

The character and use of Wendelken Interlocking Culvert Pipe made under license from The Interlocking Culvert Co., 1375 Fillmore St., Denver, Colo., are shown in the two accompanying illustrations. This pipe is particularly adapted to use where the flow line is close to the road surface, as in the Denver street here shown. In addition to the requirements of a flat top and sufficient strength to carry wheel loads practically on its own surface, the interlocking feature makes it easy to clean or to repair at any time.

Interlocking Concrete Culvert in Service.

The view of sections in the factory yard shows the character of the interlock, and the bevel which prevents side slip of the top. The reinforcement is not shown. Three sizes of block are ordinarily made—all of 24-inch inside width and with similar interlocking joints, which feature permits of six combinations giving inside heights of 10, 12, 14, 16, 18 and 22 inches.

The culvert was originally developed for purposes of side drainage; and it is interesting to note in this connection that since the first of the present year, the U. S. Bureau of Public Roads has required the installation of side drainage structures on all new construction under its supervision—that is, on all Federal Aid Projects.



Culvert Sections Set Up Showing Character of Interlock.

Waterworks and Hydraulics Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
- (a) Roads
- (b) Quarries and Pits
- (c) Streets
- (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
- (a) Water Works
- (b) Irrigation and Drainage
- (c) Sewers and Sanitation
- (d) Waterways

Railways—3rd Wednesday
- (a) Steam Railway Construction and Maintenance
- (b) Electric Railway Construction and Maintenance
- (c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures

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Will Los Angeles Build $12,000,000 Sewers by Force Account?

Having voted $12,000,000 for an enlarged sewer system, bids will soon be called by Los Angeles for its construction. We quote the following from the L. A. Express:

> When these plans are prepared bids will be advertised. More than a score of contractors were expected to bid on the work. After the bids have been received they will be carefully analyzed, and if it is found that the figure is too high, all bids will be rejected and the city will do the work by force account, it was said.
>
> Another plan that was being considered by the Department of Public Works was to take advantage of an offer made by the Department of Power and Light to lend some of its expert tunnel engineers to work on the sewage problem.
>
> Before the huge sum is spent it is believed that a number of the members of the City Council will make a careful investigation of the entire project. Councilman Mallard declared that it was his opinion that the city would save a huge sum by doing the work itself.
>
> He expressed himself as favoring the plan of having the advice and assistance of the engineers who erected the city's aqueduct. It was proposed that the same methods of construction be followed in building the sewer as was used in constructing the aqueduct.

It will be noted that the force account method of building the Los Angeles aqueduct is cited as a precedent for using the same method in building the new sewer system. We suggest that before the city again adopts the force account plan it should secure a report from disinterested consulting engineers not only as to the economy of force account work in other cities but on the Los Angeles aqueduct itself. Our own impression of the Los Angeles aqueduct unit costs is that, for the most part, they will be higher than they would have been had the work been done by contract.

It is quite natural that some engineers should like the glory of being both the designers and the construction superintendents of a great project. This was well exemplified in the building of the Panama Canal, which some of us have not forgotten cost twice its estimated cost. But it is rarely possible for an engineer to be both an expert designer and an expert superintendent of construction. Moreover, when workmen are employed by a city, there is the strongest tendency for them not to do a good day's work. They realize that the income of the foremen and superintendents over them, is unaffected by the cost of the work, and that the "owner"—the heterogeneous public—will not "fire" the foreman or superintendents if costs are running high. Fight as he may against this attitude of workmen employed by a city, a superintendent can rarely get them to do three-fourths as much work as can a contractor. More often the output of city workmen is only half to two-thirds that of workmen employed by a contractor.

If the city of Los Angeles will consult the California State Highway Department, it will learn, we believe, that force account work has usually been much more expensive than contract work. Yet the engineers of the California Highway Commission are among the ablest in the United States.

The grand error made by advocates of force account, or day labor work, arises from the assumption that the average man will work as industriously for a public employer as for a private employer. He simply will not do it, as the economic history of innumerable construction jobs shows. Hence in the effort to "save the contractor's profit" of about 10 per cent, there is usually lost more than twice that percentage in lower efficiency of the workmen.

An experienced person can distinguish a contractor's gang of workmen from a city's gang as far as he can see their motions. Indeed, even inexperienced people often comment on the lazy movements of city employees engaged in repairing pavements, cleaning streets, washing windows and woodwork in public buildings, and the like. Seeking a reason for this prevalent laziness, the common conclusion is that it is "due to politics." A much more potent reason is the absence of an adequate dollars and cents incentive on the part of men who are managing the work. The most important law of management is that payments should be proportional to performance. A contractor is paid in profits, which are proportionate to his efficiency as a manager. A city engineer or superintendent of construction is paid a salary, which seldom has any relation to his real efficiency. Occasionally such a city employee will work as hard to make his men work, as will a contractor; but this is not the rule. He cannot be popular if he does, and unless he enjoys some measure of popularity, politicians who do will eventually oust him.

Labor unions are usually "strong for" construction by day labor instead of by contract. They see in the day labor plan not only snap jobs but more jobs. It is a shortsighted policy to favor decreased individual output, but it is the policy of most labor leaders. If the city of Los Angeles believes in this labor union policy, then by all means let its new sewer system be built by day labor instead of contract.

The Engineer and Malaria

Malaria costs Louisiana $4,000,000 annually, according to its State Board of Health. To each death from malaria must be added about 3,000 days of sickness suffered by people who are not fatally afflicted. All this is traceable to the anopheles mosquito. But, according to the Annual Review of the Rockefeller Foundation, the annual cost of malarial sickness and death is greater than the annual cost of preventing malaria.

The draining of swamps and ponds is one of the means by which mosquitoes are eliminated. This is an engineering problem. Wherever malaria is prevalent, civil engineers should take a leading part in arousing the public to the economic necessity of destroying the breeding places of mosquitoes. Engineering societies should co-operate with boards of health in such matters. Approximate estimates of the cost of drainage should be made, to show that the interest on the cost is less than the annual cost of illness due to malaria.

To civil engineers must be assigned a great deal of the credit for having reduced typhoid fever by chlorinating water. In like manner we look to see civil engineers become a great factor in banishing malaria.

Classification of Revenues of Water Companies

To the Editor: In connection with the high cost of living I should like to raise the following question in connection with the high cost of accounting for public utilities, especially waterworks in connection with their revenue accounts.

All the commissions require water companies to classify their revenues from consumers into a variety of accounts, among which domestic consumers, commercial consumers, industrial consumers, etc., must show separate classifications.

In the case of a company furnishing water under a schedule of rates which charges all classes of consumers the same minimum and a service charge based solely on the size of the service or meter and a rate per 1,000 gal. of water that is the same (the water rate is stepped according to the number of gallons consumed), why should the classification of revenues provide for segregations of consumers into domestic, commercial, industrial, etc.?

This segregation costs considerable money in the way of extra office work attendant upon keeping separate ledgers and seeing that everything is properly accounted for. I have never known of this question being discussed before any of the societies nor in any of the technical journals. If the services are metered under a rate schedule such as noted above wherein is the public placed at a disadvantage by consolidating all of the consumers under one accounting classification? The only reason that I have ever heard advanced is that a domestic consumer cannot afford to stand his proportion of overhead and other burdens, and consequently he must be set off in a compartment by himself so that he shall not be maltreated by the public service company.

If the readers of Engineering and Contracting have any views on the subject I should be interested in comparing notes with them.

F. W. COLLINS.
Consulting Engineer.

50 Church St., New York City.

Cost of Drainage Construction on Federal Irrigation Projects

Up to March 1, 1922, 25.88 miles of open drain had been constructed on the Newlands Project of the U. S. Reclamation Service. The average cost, according to the report of A. W. Walker, engineer of the project, in the April Reclamation Record, was $0.969 per linear foot, or approximately $5,116 per mile.

Table I shows the total cost of each drain as constructed March 1, 1922. This cost includes excavation, structures, and overhead expense. Table II shows the field cost of excavation and the total yardage moved on each drain.

TABLE I.—TOTAL COST OF DRAINS AS CONSTRUCTED MARCH 1, 1922.

Drain.	Total cost March 1, 1922.	Linear feet constructed.	Cost per linear foot.
Carson Lake	$ 7,392.56	13,380	$0.55
L drain and branches	47,594.33	58,145	.82
New River	38,450.08	38,295	1.00
Harmon	3,240.54	4,210	.78
Kent Lake	11,127.41	5,290	2.10
Lower Soda Lake	22,252.49	15,647	1.42
New Fernley	2,447.25	1,720	1.42
Total	[1]$132,504.66	[2]136,687	[3]$0.969

[1] Exclusive of $17,428.97 for drainage investigations. [2] 25.88 miles.
[3] Average cost per foot.

TABLE II.—YARDAGE AND FIELD COST OF EXCAVATION.

Drain.	Cubic yards excavation.	Total cost, excavation.	Unit cost per cubic yard.
Carson Lake	53,617	$ 5,555.28	$0.104
L and branches	298,079	31,038.12	.104
New River	305,514	27,449.93	.090
Harmon	20,371	2,394.60	.117
Kent Lake	53,066	8,499.12	.160
Lower Soda Lake	113,759	13,602.84	.120
New Fernley	12,896	1,732.81	.135
Total	857,302	$90,272.70	[1]$0.1053

[1] Average field cost.

These prices include leveling spoil banks, moving to work, depreciation of machine, labor, supplies, oil, gas, etc., caring for telephone wires, etc.

Mosquito Eradication Campaign in Illinois City.—Carbondale, Ill., according to the August issue of the Illinois Health News, has been carrying out a campaign for the eradication of mosquitoes and the prevention of malaria, being the first city in Illinois to undertake work of this kind in a systematic manner. Though the city has a population of only about 6,000, a local fund of about $2,000 has been raised and the Illinois Central R. R., which maintains division headquarters and shops at the northern edge of the city, is expending $8,000 for draining swamps and constructing ditches. A fishing club maintaining summer cottages on a lake at the southern edge of the city is also financing the work to eliminate mosquito breeding in the lake. The work at Carbondale comprises construction of ditches, sewers, cleaning and oiling ditches and a general backyard clean-up of cans, rain-barrels, etc. The city has passed and is enforcing an ordinance which will insure that backyards be maintained free from mosquito-breeding places at all times. The state department of public health is directing the work with the co-operation of the U. S. P. H. S. and the International Health Board. The Lions Club has guaranteed the local fund and the Boy Scouts and all civic organizations are co-operating to make the work effective.

Damage to Water Mains at New Orleans, La., by Electrolysis.—According to the 44th semi-annual report of the Sewerage and Water Board of New Orleans, over 5,000 ft. of cast iron pipe and over 3,000 ft. of lead service lines had to be renewed in 1921 because of damage by electrolysis. This brings the total renewals to date for this cause to 26,950 ft. of cast iron mains from 4 in. to 16 in., and 17,921 ft. of lead services from ⅝ in. to 2 in., with a total cost of repairs to the end of 1921 of $81,155.50, of which about $24,000 was incurred during 1921.

Sewerage Improvement at Los Angeles.—Work will be started at once on the first unit of the sewer improvements at Los Angeles, Calif., to be built under the $12,000,000 bond issue approved by the voters on Aug. 29. It is expected the first unit, providing for an emergency pipe line and treatment plant to handle the excess flow of sewage from the southwestern part of the city, will be completed in four months.

Method of Constructing a 48 In. Gas Main in Chicago

Work is now well advanced on the laying of 4½ miles of 48-in. gas main in Hamlin Ave., Chicago, for the People's Gas Light & Coke Co. This improvement involves a number of interesting construction features, some particulars of which are abstracted below from the People's Gas Club News:

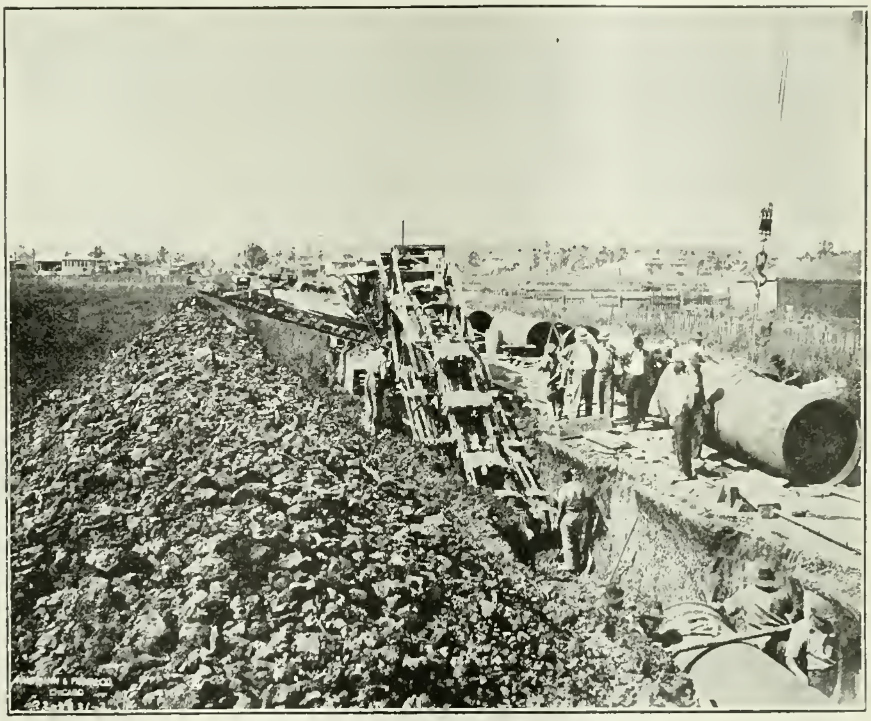
The Preliminary Work.—The grade of the southwest side of Chicago rolls gently to the north and all drainage flows to the Drainage Canal. It was decided that an easy grade be given the 48-in. main to the north and that it follow the natural contour of the ground. Two feet of cover was considered sufficient and by grading the line to the north, no drips would be necessary as the line would drain into the tunnel shaft at 39th St.

All underground work was taken care of in advance, arrangements being made with the city waterworks department to lower their mains deep enough to allow the 48-in. main to pass over them. Telephone conduits and high voltage wires were moved out of the path.

An accurate survey was made of Hamlin Ave. along the route of the main and a profile map made showing obstructions. The proposed line was laid out on this profile map and the grade established. Test holes were dug at each street intersection so that an accurate knowledge of the obstructions would be available and on record.

The Contract.—The general contract for the construction of this main was let to Nash Bros., Chicago. The contractor digs the trench, braces same, places pipe in the ditch, maintains the trench while pipe is being caulked, backfills after pipe is tested and returns street to its original condition. The gas company caulks and tests the pipe. The contract for hauling and placing the pipe along the proposed route was let separately to the W. J. Newman Co., Chicago.

The contractor moved his equipment May 10 to 71st and Hamlin Ave. and the work was started digging the trench May 15.



Trenching for 48-Inch Cast Iron Gas Main.

Digging the Trench.—Because the south end of the job was on the highest elevation, and the territory at the north end near the Drainage Canal was open country, having a gumbo soil, very soggy in the spring of the year, it was decided to start at the south end.

Nash Bros. sublet the excavating of the trench to G. T. Thorne, Oshkosh, Wis., who moved in a large Austin excavator.

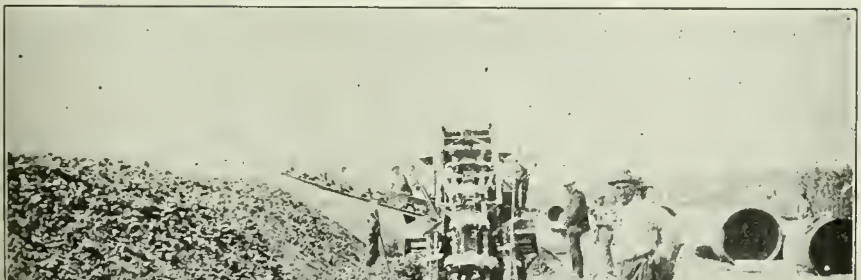
This excavator digs the trench which averages 7 ft. x 7 ft. with ease. A record of 408 ft. dug and pipe laid has been made since the actual work started an average of 204 ft. per day has been made up to Aug. 1. Figuring the expansion of the dirt from the trench, the excavation is running 2 cu. yd. per lineal foot.

An interesting feature is the method of digging the sides of the bell-holes as the excavator is working. Due to the digging being done on an incline, bell-holes were measured ahead and men with bars and shovels placed on each side to cut out the bell-holes. The dirt is thrown down on the buckets and carried out of the ditch, proving a great labor saver.

The pipe is placed in as soon as the ditch is dug, the excavator keeping a few lengths ahead of the pipe laying. The soil is a clay gumbo and in dry weather stands up remarkably well.

A stretch of dry weather, 43 days without rain, since the job began enabled the work to be carried on very rapidly and to date only single pipe braces have been necessary at each pipe.

Placing Pipe in Ditch.—For handling the pipe the contractor installed a 10-ton gasoline crane mounted on caterpillar trac-



Laying 48-Inch Cast Iron Gas Main.

tion. In order to lower the pipe slowly in the ditch and to assist in lining it straight, the single line on the hoist drum was reduced by means of a double set of blocks so that 1 ft. on the drum was reduced to a 2½ in. drop at the pipe.

The traction crane follows closely behind the excavator and it takes six minutes to lift the 48-in. pipe from the bank, place it in the trench, and drive it home.

Extreme care is taken with the laying of the pipe. Each pipe weighs approximately four tons and it was decided that the trench should be dug to grade, the blocking laid so that the top of the 4 in. blocking would be on grade, which would make the whole pipe, with the exception of the bell-hole, rest on the original, undisturbed bottom of the trench.

Constant engineering supervision carries out this plan. Levels are taken on the ditch as the excavator is working, on the blocking before the pipe is laid and on the pipe line after laying for a permanent record.

Caulking the Joints.—The company maintains its machinery for caulking and does this work with its own forces.

Immediately the pipe is placed in the trench, the bell-holes are dug in preparation for the caulkers. At no time during the progress of the work so far have the caulkers been more than 25 joints behind the last pipe laid.

The joints are 5 in. deep and are caulked with 3 in. wool yarn and 2 in. lead wool. Caulking is done by pneumatic hammers and two men work to each joint. It requires approximately 8 lb. of wool yarn and 126 lb. of lead wool per joint. Two men average two joints per day. One hundred and twenty-seven thousand five hundred pounds of lead wool and 8,160 lb. of yarn have been used so far on this job.

Compressed air is supplied by three Ingersoll-Rand portable compressors capable of supplying a maximum of 210 cu. ft. per minute each at 100 lb. pressure. A header line runs along the trench and two compressors work on the line. At times as high as fourteen sets of caulkers, 26 hammers, have worked from this header line.

A unique arrangement of the compressors and header line makes a very efficient lay-out. The header line is run two city blocks about 600 ft. ahead of where the caulkers are working and by aid of the extra compressor, two compressors are always on the line when one is being moved ahead or the compressors being moved into a new position.

Handling Surface Water.—As precautionary measures against drainage surface water it was decided to have on the job three Schramm pumps having a capacity of 50 gal. per minute each. A header line was laid along the top of the trench and 12 ft. lengths of hose connected by unions to this header line and lowered into each bell-hole where there was water. This method proved very satisfactory where water was encountered.

Testing the Pipe.—The progress of the work is so arranged that the digging and laying of the pipe ends Saturday noon. All uncompleted joints are finished up Saturday afternoon and Sunday if necessary.

The 48-in. plug is put in the last pipe by means of the traction crane. When the last joint has been caulked, the three compressors are hooked up to the line and it has been found possible to secure 15 lb. pressure in the line inside of eight hours.

The tests have been cumulative up to the present time, testing each week's work in addition to the work that has been finished previously. Up to Aug. 1 a length of pipe from 71st St. to 52nd St. on Hamlin Ave., a distance of 12,500 ft., has been successfully tested.

Backfilling.—The contractor is backfilling with an Austin backfiller and puddling the dirt by means of a fire hose connection to fireplugs at street intersections.

Excess dirt, which runs to nearly ¾ cu. yd. per lineal foot of ditch, is being loaded by a clam-shell crane on traction wheels into auto dump trucks and hauled away from the job to be wasted.

The route of the 48-in. main passes through some of the main water lines of the city of Chicago. At 65th St. it was necessary to lower the 30-in. water main supplying the large Clearing manufacturing district. This main had to be cut out and lowered 8 ft.

Progress and Completion.—An average of 186 ft. per day has been made since the work started. If the present rate of progress is maintained the whole line should be laid and gas turned in same by Nov. 1.

The laying of this 48-in. gas main is being done under the direction of John H. Eustace, Chief Operating Engineer. W. G. Rudd, Assisting Operating Engineer, is in charge of the engineering details. Actual supervision and construction is carried on by the Department of Streets, C. L. Day, General Superintendent, through John Ginley, Assistant General Superintendent, South Division.

Engineers' Registration Boards Meet

Reciprocal registration of engineers will be considered by the Council of State Boards of Engineering Examiners which meets in Chicago at the Congress Hotel on Oct. 2. This board consists of a representative from each state board, but in many cases it is expected that the entire state board will attend this important meeting.

A tentative plan will be submitted at the meeting, according to C. S. Hammatt, president of the National Council, whereby the several state boards can make operative for reciprocal registration the several state laws without changing the laws, which would be a long and uncertain procedure. A solution of reciprocity between the states which would permit a man registered in one state to practice in other states will mean much for the public and the engineering profession. It is believed that a suitable qualification can be agreed upon.

Following are the various state registration boards and secretaries:

Arizona—G. M. Butler, Chairman, State Board Registration, University of Arizona, Tucson, Ariz.

Colorado—R. G. Hosea, Department State Engineer, State Capitol, Denver, Acting Secretary Colorado Board of Engineering Examiners, Secretary Council State Boards of Engineering Examiners, 1921-22.

Florida—C. S. Hammatt, President, Florida Board of Engineering Examiners, 215 E. Bay St., Jacksonville, Fla, President Council State Board of Engineering Engineers. 1921-22.

Idaho—Robt. O. Jones, Commissioner of Law Enforcement, Boise, Ida.

Illinois—T. L. Condron, Condron Co., Monadnock Bldg., Chicago, member Illinois Board of Inspection.

Indiana—DeWitt V. Moore, Secretary, Indiana State Board of Engineering Examiners, State House, Indianapolis, Ind.

Iowa—K. C. Kastberg, Secretary, Iowa State Board of Engineering Examiners, Des Moines, Ia.

Louisiana—Marcel Garsaud, member Louisiana State Board of Engineering Examiners, 815 Maison Blanche Annex, New Orleans, La.

Michigan—John J. Cox, Secretary, Michigan State Board of Engineering Examiners, Detroit, Mich.

Minnesota—Paul Doty, Chairman, State Board of Registration for Engineers, 427 Portland Ave., St. Paul, Minn.

New Jersey—Hugh A. Kelly, Secretary, State Board of Professional Engineers and Land Surveyors, Jersey City, N. J.

Cost of Water Purification at Cincinnati, O.—The accompanying tabulation from the recently issued report of the Waterworks Department of Cincinnati, O., covering the years 1919, 1920 and 1921, shows the cost of purification per 1,000,000 gal. of filtered water delivered for consumption for the years 1908-21:

	Operation			
Year.	Coagulating chemicals.	All other operating costs.	Maintenance.	Total
1908	$1.72	$2.47	$0.05	$4.24
1909	1.89	2.28	.09	4.26
1910	1.93	1.98	.28	4.19
1911	1.86	1.91	.35	4.12
1912	1.78	1.68	.38	3.84
1913	1.67	1.77	.48	3.92
1914	1.21	1.78	.39	3.38
1915	1.43	1.86	.76	4.05
1916	1.27	1.80	.38	3.45
1917	1.86	1.85	.40	4.11
1918	2.12	2.37	.67	5.16
1919	2.34	2.55	.99	5.88
1920	2.15	2.73	1.04	5.92
1921	2.41	2.44	2.16	7.01

Filter Sand at Chain of Rocks Purification Plant, St. Louis, Mo.—The annual report of the Water Commissioner of St. Louis, for year ending April 1, 1922, states that the filter beds at the Chain of Rocks purification plant have an average depth of 26.34 in. of sand which represents a loss in depth of 3.7 in. since the plant was put in operation seven years ago. The coating on the sand after jetting amounts to 10 per cent of the weight of the sand or an increase of 5 per cent since it was first jetted two years previous.

Surge Tanks

With the growth of the size of power plants has come the increasing length of closed conduits. Where these are used in conjunction with turbine installations, it becomes advisable, and in some cases necessary, to use surge tanks in order to prevent excessive water hammer when the turbine rejects load. In this type of power plant, it also becomes necessary to water storage near the plant, so that the load on the plant can be increased as fast as modern operation requires. A surge tank designed for this last condition will also relieve surges or prevent them from entering the long closed conduit. In a paper in the April Proceedings of the American Society of Civil Engineers, Mr. B. F. Jakobsen, Designing Engineer of the San Joaquin Light & Power Corporation, Fresno, Calif., shows the distinction between surge tanks for acceleration and deceleration, and the distinction between the requirements for medium high-head plants and for high-head plants. An abstract of the paper follows:

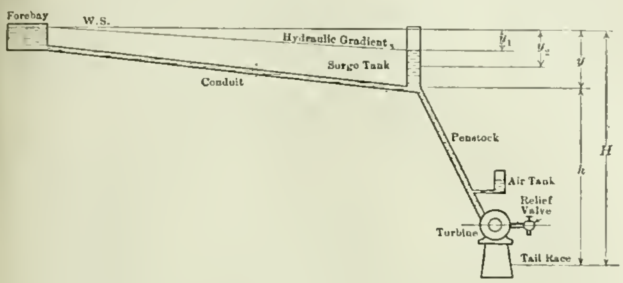


Fig. 1.

Typical Surge Tank Installation.—Figure 1 shows the tank located at the lower end of a long closed conduit and at the top of the penstock. The object of the surge tank is to relieve surges which travel up the penstock, when the turbine is rejecting load and to furnish water to the turbine when the load is increased, since the gradient of the long conduit seldom suffices to provide the maximum acceleration needed for satisfactory regulation and operation of the plant.

Surge tanks may be divided into two general classes, depending on the main object to be obtained:

1. Surge tanks designed so as to allow the plant to take on load rapidly, and to spill on load rejection of no consequence.
2. Surge tanks designed primarily to prevent spilling, on load rejection.

Case 1.—Rapid Acceleration, as Shown in Fig. 2.—The water storage lies just above the lower end of the long closed conduit. With a certain load on the plant the drawdown is y_1 ft., as indicated. If the load is rapidly increased, the surge tank must supply the additional water, and the level of the water in the surge tank will be quickly lowered to the top of the storage chamber. In this design, the maximum accelerating head is made available for the long conduit practically from the start, and this, therefore, permits the use of the smallest possible surge tank. If, however, y is a considerable part of H, as it is likely to be with medium high-head plants having long conduits, the head on the turbines is lowered at the time it is most needed, and the lowering of the head in the surge tank operates to decrease the total available output of the plant. To overcome this disadvantage, the storage must be somewhat distributed, as discussed subsequently.

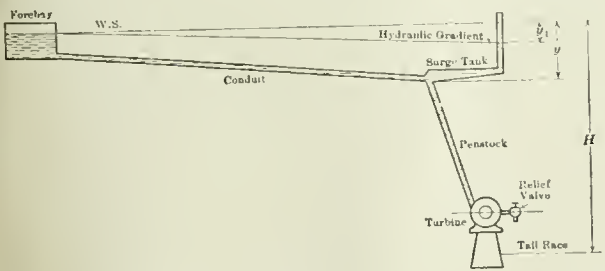


Fig. 2.

Case 2.—Rapid Deceleration, as Shown in Fig. 3.—It is evident that with Case 2, the storage should be placed as high as possible without additional cost, in order to reduce to the least possible its volume. The type of surge tank, shown in Fig. 3 will be only of small assistance to the plant when the load is increased. The combination of Fig. 2 and Fig. 3 would have the advantages of both, but the disadvantage, due to the lowering of the head on the turbine when the load is increased, will still remain. With medium high-head plants, or where y, Fig. 1, is a considerable part of H, it will generally be advisable to distribute the storage so that the two types of surge tanks develop the shapes shown in Fig. 4 and Fig. 5.

Surge Tank for High-Head Plants.—With plants where y is a considerable part of H, the surge tank shown in Fig. 2 will be the most advantageous. It may be a circular conduit, built slightly above the roof of the tunnel and inclined just enough to insure proper operation. This conduit may be a short section of tunnel or of pipe. Fig. 6 shows a vertical section of such a surge tank, which tank was designed by Mr. Jakobsen in connection with the plant of the Homestake Mining Co. in South Dakota, and was built by F. G. Baum, A. L. Wilcox acting as construction engineer.

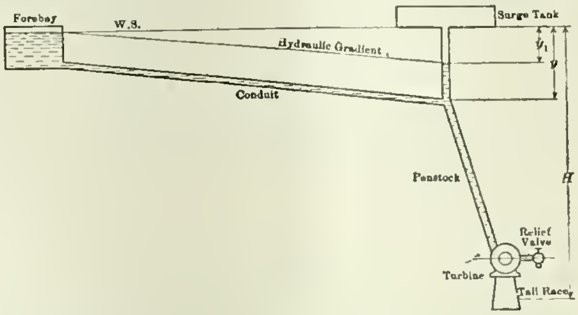


Fig. 3.

The computations for such a tank are comparatively simple, since it may be assumed that the water surface is instantly lowered and, therefore, the head y operating on the water in the tunnel or long conduit may be assumed to be constant without introducing any great error. This assumption simplified the computations.

Surge Tank for Medium High-Head Plants.—Figure 4 represents the design proposed by Mr. Jakobsen for plants where y is a considerable part of H. This shape of tank has the advantage that its area increases as the hydraulic gradient is lowered, that is, as the maximum accelerating head decreases, and a surge tank of this general shape, therefore, has its storage where it is most needed.

Where the surge tank is excavated in solid rock, as at the Kerckhoff Power Plant, the cost of excavating is practically independent of the shape of the tank, and one similar to that shown in Fig. 4 will give the least excavation and, therefore, the lowest cost. If the tank has to be built of reinforced concrete, the shape shown in Fig. 4 may cost more than that shown in Fig. 5 for equal volumes, and the problem is complicated by the additional fact that the shape of the tank influences its cost.

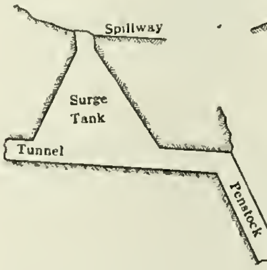


Fig. 4.

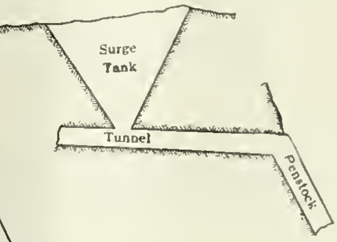


Fig. 5.

The Kerckhoff surge tank, shown in Fig. 7, is 17 ft. in diameter at the top and 39.5 ft. in diameter at the bottom. These dimensions were decided on after a few trial computations with various assumed load changes, and after deciding, in consultation with the operating department, the extreme load change that the plant must meet. Mr. Jakobsen knows of no general method of determining the most economical shape of tank. This will vary, with the assumed load change. The tank giving the smallest cost for the extreme load change it is able to take care of, will generally be the one to select. The smaller diameter should be selected so as to give satisfactory spilling conditions when load is rejected by the plant.

Kerckhoff Surge Tank Test.—The Kerckhoff surge tank and the hydraulic data for the conduits are shown in Fig. 7. The tunnel, which is about 18 by 18 ft., with a slightly arched roof, has an average area of 320 sq. ft. The power plant has three turbines, each of 15,000 H.P. maximum rating at 315 ft. effective head, connected to 14,200-kv-a. generators. The three penstocks, which are 8 ft. in diameter at the top, tapering to 7 ft. at the bottom, average in length about 930 ft. This plant, built by the San Joaquin Light & Power Corporation, was put on the line in August, 1920. R. C. Starr is construction engineer, and Mr. Jakobsen is designing engineer for the company. L. O. Wolcott made most of the computations for the surge tank.

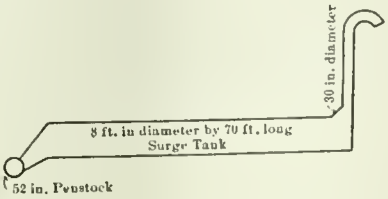


Fig. 6.

To determine how closely the computations check with tests, several load-on and load-off tests were made on Oct. 16, 1921, under the general supervision of E. A. Quinn, General Superintendent of Operation.

It was intended to obtain the surge tank readings by means of a Bristol gage which was connected to a bulb placed in the bottom of the surge tank, but, during the first test, the bulb broke and could not be replaced in time for the test. It was necessary, therefore, to measure the water surface in the surge tank by a float tied to the end of a steel tape. As one of the units was connected to the system of the Pacific Gas & Electric Co., the load on it could not be varied. The other two units were used in the test, the load being transferred as needed between the Kerckhoff plant and the steam plants at Bakersfield and Midway, Calif.

Two tests with load on and two tests with load off were made. During the second load-on test, the tape broke so that the data are not complete. Table I gives one test for load on, and Table II, one test for load off. The watt-meters in the power house were read by the power-house crew, under the supervision of Mr. Goldsworthy, Superintendent of the plant, and the surge tank readings were made by L. J. Moore, Executive Engineer. The load was transferred from or to the Kerckhoff power house as fast as possible without too great variations of the frequency of the system.

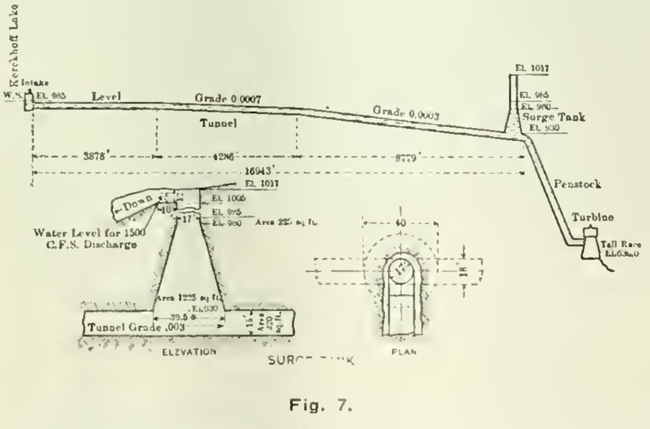


Fig. 7.

TABLE I—LOAD-ON TEST.

Time, in seconds.	Load on Generators, in Kilowatts. No. 1.	No. 2.	No. 3.
0	0	0	9,000
15	1,000	2,500	No reading
30	4,000	6,500	No reading
45	6.000	8,500	No reading
60	10,000	8,000	No reading
15	9,500	8,500	No reading
30	10,500	9,700	No reading
45	10,500	10,250	No reading
120	9.600	10,250	8,000

TABLE II—LOAD-OFF TEST.

Tie, in seconds.	Load on Generators, in Kilowatts. No. 1.	No. 2.	No. 3.
0	10,000	7,500	8,500
5	8,000	6.500	No reading
10	4.000	3,000	No reading
15	500	0	No reading
20	0	0	No reading
0	0	0	8,500

The readings of the elevation of the float in the surge tank were taken at intervals of 15 seconds. As noted in Table 1, the load on Generator No. 3 was read only at the beginning and at the end of the test. In plotting the load, it was assumed that this decreased roughly in the same proportion as the load on the other two units increased. In order not unduly to complicate the check computations, the load was assumed to increase uniformly from 9,000 to 27,850 kw. in 70 seconds.

The quantity of water was estimated as follows: With Generator No. 3 carrying 9,000 kw. and Generators Nos. 1 and 2 carrying no load, but operating at synchronous speed, the elevation of the water in the surge tank was 981.5 ft. and in the tail-race, 636.0 ft., thus giving an effective head of 345.5 ft. The water required at no load was about 16 per cent of that required at full load, but 17 per cent was assumed, to allow for water taken by the exciter, the load on which varied from 67 to 109 kw., and cooling water for the step-bearings and the transformers. The maximum load of one unit is approximately 18,700 H.P., so that the load required for one unit is about 3,180 H.P., or 162 cu. ft. per second, for the two machines. The water required by Unit No. 3, carrying 9,000 kw. with a turbine efficiency of 96 per cent and with a friction head of 5.0 ft. in the penstocks, was 374 cu. ft. per second, so that the total water at the start was 536 cu. ft. per second. Likewise, the water required at the close of the test, with 27,850 kw. on the plant and with the water in the surge tank at Elevation 970.2, was determined as 1,182 cu. ft. per second. This quantity was incorrectly estimated as 1,145 cu. ft. per second, but as this error is only about 3 per cent, it was thought not worth while to recompute this test, since the surge tank was excavated from solid rock, and its dimensions most likely vary more than 3 per cent.

The friction loss in the tunnel was the difference in the elevations of the water in the surge tank and of Kerckhoff Lake which, throughout the test, was 984.2. For 536 cu. ft. per second, the elevation of the water in the surge tank was 981.5, and for 1,145 cu. ft. per second (should have been 1,182 cu. ft. per second), it was 970.2, thus indicating a friction loss in the tunnel of 2.7 ft. and 14 ft., respectively. This corresponds roughly to Kutter's $n = 0.032$. The actual surge was slightly less than the computed surge, probably due to the fact that the load as assumed did not coincide with the actual load and, also, because the surge tank may be slightly larger than that called for in the design.

At the start, the load was 26,000 kw. The time, as taken by a stop-watch, from the start of the test until the water reached its highest elevation at 1,008.5, or 3.5 ft. above the spillway lip of the surge tank, was 25 seconds, which agrees within 1 second with the computations. The elevation of the first downward surge was not taken on account of the rapid motion of the water surface, but Mr. Moore, who took these measurements, stated at the time of the test that he thought the water was at about Elevation 968, whereas the computations give 963. A measurement on the second downward surge was taken, but the time was not noted. The time from the second upward surge to the second downward surge was taken by a stop-watch as 60 seconds, whereas the computations show 62 or 63 seconds. The somewhat larger computed surges were due to the operation of the relief valves at the turbines. These valves have a discharge capacity of 50 per cent of the full load discharge of the turbines, so that when fully open, each relief valve would discharge about 275 cu. ft. per second. No means of measuring this discharge was available.

Convention of National Drainage Congress.—The 11th annual convention of the National Drainage Congress will be held Sept. 25-29 in the Convention Hall, Kansas City, Mo. In connection with the convention there will be an industrial exhibit in which it is expected over 50 exhibitors will take part. The Levee and Drainage Contractors' Association also will hold its annual meeting Sept. 26 and Sept. 27, at the Baltimore Hotel, Kansas City, Mo. Richard S. Green, 527 Shukert Bldg., Kansas City, Mo., is Secretary of the National Drainage Congress.

Operation of Sewage Treatment Plants

Useful suggestions on the operation of sewage treatment plants are given in a little booklet prepared by Burns & McDonnell, Consulting Engineers, Kansas City, Mo. Extracts from the guide are reprinted below.

Nature of Sewage.—Great variation in quantity and quality of sewage exists in different cities, due to entrance of seepage water, roof water, and industrial wastes into the sewers. For economical and efficient operation of a treatment plant it is desirable that a minimum of seepage and no roof water be allowed to enter. Fresh sewage is desired for Imhoff tank treatment. Some industrial wastes, such as tar and oil from gas plants and refineries and washings from garages are particularly troublesome; stringent regulations should be enforced by cities to prevent such wastes from reaching the sewers to keep their treatment plants operating efficiently.

By-Passes.—No raw sewage should be by-passed except when absolutely necessary.

Grit Chambers.—Screens should be cleaned at least once per day and more often if necessary.

Grit chambers should be cleaned out whenever the accumulation of grit becomes such that grit tends to wash through; removed contents should be buried, or dried on sludge bed.

Septic Tanks.—Inlet and outlet channels and weirs should be kept clean.

Sewage solids will accumulate as settled sludge or floating scum; contents of tank should be disturbed as little as possible. When combined depth of scum and sludge equals one-quarter of the tank depth, the solids should be removed, preferably in spring or fall, when sludge will dry quickly.

Removed material may be buried, or dried on sand beds. No open flame lamps should be taken into any septic tank on account of the explosive character of accumulated gases.

IMHOFF TANKS.

Channels.—All channels should be cleaned at frequent intervals and always before reversal of flow, using care that deposits are not washed into tanks.

Settling Chambers.—When putting Imhoff tanks into service for the first time, or after pumping out and cleaning, if sewage is concentrated and flow heavy, the tanks should be filled with the more dilute night flow or clear water and the amount of sewage admitted to the tanks gradually increased, in order to build up the bacterial action.

Non-settleable material, such as oil and grease, should be skimmed off daily, burying or burning it.

Settleable material behind baffles and scum on surface of settling chambers should be skimmed off daily, throwing it into gas vents.

All vertical walls and sloping bottoms of settling chambers should be cleaned with rubber squeegees slowly, forcing the deposit entirely through the slot, taking care that the deposit is not stirred up and carried into outlet.

When reversing channels are provided the flow through the tanks should be reversed every week or two, previously skimming off all floating materials behind inlet baffles and squeegeeing all wall surfaces between baffle and end wall at inlet and allowing time for settlement.

Gas Vents.—The scum in the gas vents should be broken up daily by sprinkling with water or agitating with a rake to release the entrained gases and any material which cannot be made to settle should be removed and buried or burned.

If foaming occurs and cannot be controlled, the city should advise with its consulting engineer or the sanitary engineer of the State Board of Health.

Sludge Chamber.—Sludge should not be allowed to accumulate nearer than eighteen inches to the slot at the bottom of the settling chamber. The surface of the sludge may be determined by means of a wood or sheet iron plate attached to a wire or light rod.

Sludge should be removed at intervals by opening valves slowly on sludge pipes, it being better to remove small amounts frequently than large amounts infrequently.

Sludge should be drawn off slowly to allow continuous settlement of sludge around base of sludge pipe; only well-digested sludge should be withdrawn, known by its brownish-black color, more or less granular and frothy appearance, and faint tarry or rubbery odor as opposed to the grayish color, sticky and pasty appearance and foul odor of partly digested sludge.

Late each fall the entire amount of digested sludge should be withdrawn to provide sufficient storage capacity for winter sludge.

Vertical and horizontal sludge pipes should be cleaned by rodding to break up old deposits before opening valves. The sludge pipe may be backfilled with water or settled sewage after drawing sludge.

At intervals of several years, dependent upon local conditions and kind of plant operation, the tanks may require to be pumped out and cleaned out thoroughly.

SLUDGE BEDS.

Sludge should not be drawn upon the bed until all dried sludge has been removed therefrom; well-digested sludge only should be dried upon the bed and should be drawn to a depth preferably not over six to eight inches and never over twelve inches.

When thoroughly dried the sludge should be removed, being careful to remove as little filter sand as possible, and may be used for filling in low places without nuisance, or for lightening and furnishing humus to heavy soils.

Thin layers of sand should be applied to the bed from time to time to compensate for losses during removal of sludge.

DOSING CHAMBER.

Before starting the siphon should be filled with water and all pipe connections to the siphon should be kept continuously air-tight.

The sides and bottom of the dosing chamber should be cleaned down occasionally, and all floating material should be skimmed off frequently.

SPRINKLING FILTERS.

Sprinkling nozzles should be examined daily and kept clean.

The surface of the stone should be kept free from leaves, papers and vegetable growth.

In case organic growths in the bed and mothflies with their larvae become troublesome, chemicals such as caustic soda, copper sulphate or hypochlorite of lime may be used in proper quantities for their control.

When the condition of the surface becomes such that free percolation is not secured, the surface stone should be removed, washed, screened and replaced; at longer intervals, dependent upon kind of operation and quality of stone, the entire bed may require washing and screening.

FINAL SETTLING TANK.

The sludge should be removed frequently so that it will not become septic.

CONTACT FILTERS.

The apparatus for filling and emptying the beds should be examined frequently and kept in perfect operation.

The surface of the stone should be kept free from foreign material and vegetable growth.

When the stone becomes clogged with sewage solids, at intervals of five years, more or less, the entire bed of stone will require to be removed, washed, screened and replaced.

SAND FILTERS.

Sand beds should be dosed alternately to allow cleaning, resting and drying. The distributors should be regulated to secure even distribution of sewage.

Before dosing any accumulated sludge should be removed and the bed raked lightly to a depth of one-half inch to break the surface.

When the bed becomes clogged so that sewage will not percolate, the surface sand should be scraped off to a depth of one inch and raked. At longer intervals new sand of suitable quality must be added to the bed.

Teams and heavy loads should not be driven over the bed. Holes should not be dug into the sand to pass sewage directly to drains and any wash-ins should be repaired at once. No growth of vegetation should be allowed on the bed.

In the northern states the sand should be piled or ridged in late fall for winter operation to prevent ice from freezing to the sand, and every opportunity utilized for cleaning the bed.

A Page from Recent Waterworks Reports

Filter Plant Operations at St. Louis.—The following note is taken from the annual report of Edward E. Wall, Water Commissioner of St. Louis, for the year ending April 1, 1922:

During the year, 38,871 million gallons of water were filtered at a cost of $4.44 per million gallons. The cost per million gallons includes the cost of operation, maintenance, repairs, light, power, coal and the chemicals used in the applied and filtered water. There were 4,889 filter washings during the past year; 510.66 million gallons of water were used for this purpose or 1.31 per cent of the water filtered. The rate of filtration has varied during the year from a maximum of 98.31 million gallons per acre per day to a minimum of 74.35, the average for the year being 83.37 million gallons per acre per day. The maximum run of a filter was 237.58 hours filtering 26.33 million gallons; the minimum was 11.16 hours filtering 1.39 million gallons; the average being 70.98 hours and filtering 7.95 million gallons. The 40 filters were continually in service except for short periods when minor repairs were being made to individual units. The rate of washing filters was changed in December, 1921, from 15.7 to 15.0 gal. per square foot per minute, as some of the finer sand was being washed over at the higher rate. By washing at the present rate mud-balls have not increased in size or number. Once each month a ¼-in. screen is pulled through one section of each half of filter when washed, the mud-balls are then counted and in this way a good check is kept on the condition of the sand bed. During the month of October, 1921, the rating of filters was changed from one-half to one hour at the half million rate after washing, to allow the sand bed more time to settle, before running water through at the faster rate.

Water Consumption at New Orleans.—Notwithstanding more new connections than usual, the total water consumption in New Orleans in 1921 did not increase materially over that of the preceding year. From 1915 to 1920, inclusive, the water consumption increased annually by an average of nearly 10 per cent per annum. The increase for 1921, according to the 44th semi-annual report of the Sewerage and Water Board, was only about 1 per cent, and the amount of water used by large consumers showed a marked decrease. The total amount of water metered to pay consumers, however, increased a great deal more than the total consumption, viz., about 4 per cent, while the total revenue from water rates only increased about 1.4 per cent. Water through pay consumers' meters, however, in this comparison includes the material amount which is deducted from practically all consumers' bills as free water for sewerage uses; it also includes water which is not paid for in the case of allowances made for wastes on account of broken pipes, etc., after same are shown to have been repaired. These allowances amounted to $48,000, being one-third larger in 1921 than in 1920. It also includes metered water charged to, but not paid by the Board of Commissioners of the Port of New Orleans, whose meters showed an aggregate consumption of 201,000,000 gal., beside a large amount of unmetered water used by the Board.

Effect of Water Softening at St. Louis.—A saving of $920 per day in soap alone was effected last year by the softening of the municipal water supply of St. Louis, according to the annual report of the Water Commissioner for the year ending April 1, 1922: The total reduction in hardness, due to removal of part of the dissolved bicarbonates of calcium and magnesium present in the river water, was 72 parts per million. Fifty-one per cent of the calcium and 20 per cent of the magnesium present in the river water were removed by the added lime. The scale forming solids were reduced from 1.36 lb. per 1,000 gal. in the river water to 0.73 lb. in the tap water. The saving in soap effected by the reduction in hardness of 72 parts per million, based on a price of 8 ct. a pound for soap, amounts to $1.15 for every 1,000 gal. of water used for washing purposes. Allowing 1 gal. per inhabitant per day as the average quantity used for washing purposes, the total saving per day would be $920, or $335,800 for the year.

Comparative Data on Operation of Filter Plants at Reading, Pa.—The following table for the 56th annual report covering the year 1920 of the Bureau of Water at Reading, Pa., gives comparative data and unit costs of operation of the four filter plants of the city.

	Egelman.	Antietum.	Bernhart.	Maiden Creek.
Length of service in years..	17.6	15.6	9.6	7.3
Years in actual operation...	17.6	15.6	9.6	5.6
Average gal. water filtered per day	318,919	3,039.847	2,520,111	11,725,878
Average rate of filtration, gal., per acre per day.....	3,307,645	2,863,662	1,886,186	2,564,153
Average gal water filtered between scrapings	4,835,499	46,900,011	72,127,498	248,581,065
Average quantity of water filtered between scrapings, gal., per acre........	50,151,032	44,181,758	53,984,086	54,358,390
Average cu. yd. of ice removed, annually	129	1,052	....	....
Average cost of ice removal, per cu. yd.	$0.187	$0.102	....	....
Average cost of ice removal, per million gallons of water filtered	$0.208	$0.096	....	....
Average annual quantity of sand scraped and wheeled out, in cu. yd.	228	1,879	....	....
Average cost of sand removal, per cu. yd.	$0.732	$0.692	....	....
Average cost of sand removal, per million galions of water filtered	$1 439	$1.169	$0.358	$0.338
Average annual quality of sand washed, in cu. yd...	213	1,799	....	....
Average cost of sand washing, per cu. yd.	$0.770	$0.409	....	....
Average cost of sand washing, per million gallons of water filtered	$1.413	$0.660	....	....
Average annual quantity of sand refilled, in cu. yd. ...	213	1,798	....	....
Average cost of refilling sand, per cu. yd.	$0.331	$0.490	....	....
Average cost of refilling sand, per million gallons of water filtered	$0.609	$0.791	....	....
Average cost of washing and refilling sand, per million gallons of water filtered	$2.022	$1.451	$1.078	$0.924
Average cost of operation and general maintenance, including watching, per million gallons of water filtered	$1.415	$0.636	$0.672	$0.367
Average cost of analyses, per million gallons of water filtered	$2.881	$0.311	$0.693	$0.261
Average cost of care of grounds, per million gallons of water filtered	$0.657	$0.622	$0.880	$0.675
Average cost of all operations, per million gallons of water filtered	$8.618	$4.286	$3.681	$2.566
Average cost of filtering water, omitting cost of analyses and care of grounds, per million gallons	$5.080	$3.352	$2.108	$1.629

1920 Vs. Pre-War Costs of Waterworks Operation at Reading, Pa.—An interesting comparison of the costs and revenues of the waterworks of Reading, Pa., for the year 1920 and for the fiscal year April, 1913, to April, 1914, is given in the 56th annual report (1920) of the Bureau of Water of Reading, Pa. The statement follows:

Item.	1920 cost.	Pre-war cost.
Pumping water, per million gallons	$17.40	$ 5.97
Pumping water, per one foot high (dynamic)........	0.078	0.025
Supplying water, per million gallons, figured on total maintenance	53.39	15.62
Administration charges, per million gallons	2.93	1.00
Control clerk's office charges per million gallons	1.40	0.67
Chief engineer's office expenses per million gallons.	1.02	0.84
Maintaining gravity supplies and reservoirs, per million gallons	9.04	5 33
Maintaining distribution system, per million gallons.	3.31	1.62
Filtering Egelman water, per million gallons	11.53	6.95
Filtering Antietam water, per million gallons	6.95	3.15
Filtering Bernhart water. per million gallons	3.96	4.03
Filtering Maiden Creek water, per million gallons ..	4.21	1.15

	1920 revenue from sale of water.	Pre-war revenue from sale of water
Per million gallons supplied	$47.96	$48.41

Cost of Repairing Meters at Cincinnati, O.—The following table from the report of the Water Department of Cincinnati, O., for the years 1919-21 shows the average cost to the department of repairing meters, including test charges:

Size.	December, 1919. Per meter.	December, 1920. Per meter.	December, 1921. Per meter.
⅝-in.	$ 4.01	$ 4.26	$ 4.27
¾-in.	4.69	5.20	4.65
1 -in.	5.61	5.85	5.72
1½-in.	9.97	10.10	9.30
2 -in.	11.07	11.89	12.15
3 -in.	10.80	15.69	10.59
4 -in.	17.55	16.01	18.14
6 -in.	.....	4.00	*27.00

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*One meter only.

Stream Pollution Investigations

Recommendations as to Plan and Policy Made by United States Public Health Service Consultants in Stream Pollution Investigation Work

For a number of years past the U. S. Public Health Service has been engaged in a fairly extensive study of problems relating to the sewage pollution of interstate and navigable waterways. The work undertaken has comprised laboratory studies of the fundamental biochemistry of sewage disposal and water-purification; experimental studies of methods for the treatment of sewage and industrial wastes; fairly extensive studies of sewage disposal by dilution in several typical waterways; surveys of the pollution of coastal waters, with special reference to contamination of shellfish; and co-operation with states and municipalities in the study of a number of local problems. In the summer of 1921, upon request of the Surgeon General, Dr. Stephen A. Forbes, professor of biology, University of Illinois; Dr. Edwin O. Jordan, professor of hygiene and bacteriology, University of Chicago, and Mr. Langdon Pearse, sanitary engineer for the Sanitary District of Chicago, very generously consented to serve as consultants. Since their appointment, these consultants have been in close touch with the work now in progress, through periodic conferences with the officers of the Public Health Service engaged in the field work and reports of current progress.

Desiring to obtain the benefit of their advice in the further development of this work, the Surgeon General recently requested them to submit a full and free expression of their opinion as to the general lines to be followed in future work, quite independent of the plans at present being pursued. Their joint memorandum is printed in a recent issue of Public Health Reports. The memorandum, practically in full, follows:

Broad Powers of Public Health Service.—The act under which the United States Public Health Service operates provides:

> The Public Health Service may study and investigate the diseases of man and conditions influencing the propagation and spread thereof, including sanitation and sewage and the pollution, either directly or indirectly, of the navigable streams and lakes of the United States, and it may from time to time issue information in the form of publications for the use of the public.

Under this act it would seem that the United States Public Health Service is empowered, at its discretion, to carry on research in sanitary matters, as well as in pure science. The scope is very broad. There appears to be no direct order, as the word "may" is used, not "shall." We believe that this discretion should properly be exercised and that there are legitimate functions which the service can well perform along the lines hereinafter indicated in sanitary research and field investigation.

The present and probable future resources of the service for sanitary work, both in the field and along the lines of research, would seem to be excellent, inasmuch as we believe that exercise of the proper functions of the service will keep in the organization a compact body of trained specialists in biology, chemistry, bacteriology, and allied sciences, who can indicate the proper fields of investigation for extended research.

Present Tendency Regarding Stream Pollution.—The present status of the stream-pollution problem and its regulation in the United States is somewhat unsettled as regards any established policy throughout the country. There has been, however, a definite trend in the last 20 years towards improving the condition of streams, and, in particular, those streams in which the nuisance is marked. The tendency today is also towards the improvement of streams from which water supplies are taken, and further consideration is being given to the conservation of fish life by stream cleaning. The probability is that, as the country becomes more thickly populated, there will be further pressure for better stream conditions, not only from the standpoint of nuisance, but also to relieve the load upon water-treatment plants using such streams as sources of supply. In so far as the stream pollution problem itself is concerned, the status and tendency seem to be fairly clear, with a trend towards the bettering of conditions of the waterways. On the other hand, the status and tendency of regulation are somewhat clouded by the variation in the different States having authority to act within their borders. This is further complicated by the lack of police powers in many States. A general tendency seems to be to give a central body, like the State Board of Health, sufficient control, in a discretionary way, to advise on sanitary problems in stream pollution. There has not been, as yet, any marked inclination to follow the lead of Ohio in permitting the State to order work constructed under certain stipulated conditions. From the standpoint of regulation of industrial waste pollution, while there is considerable activity, so far this has not always led to a complete solution of the problem, owing to the cost of treatment. The industrial waste problem seems to have been one of more or less local handling, the practice of each State varying considerably. In some States no attempt is made to regulate at all. The indications are, however, that even in States containing the most industries, conditions have come to such a pass that even the industries realize that something must be done. This would seem to favor well-considered action towards regulation.

Regulation of Stream Pollution.—The resources of the State, municipal and private organizations for necessary studies of stream pollution appear to be somewhat limited. Only the largest organizations have undertaken such work in the past, and then often with limited funds. Where difficulties are traceable to private organizations it would seem desirable that those organizations bear at least part of the expense of investigation. There appears to be, among the different agencies able to investigate, a lack of co-ordinated effort to avoid duplication of activities and to advance the work as far as possible.

It would seem that the States and municipalities had sufficient potential authority to regulate stream pollution within their respective boundries. The responsibility for such regulation might be enlarged. As expressed above, police authority is frequently lacking. It would seem that more uniform laws and practice were desirable; in other words, co-operation of the States interested in an interstate problem through some national agency.

It therefore seems to us that the Public Health Service has, if it desires, a very definite function to perform in the handling of interstate problems of stream pollution and in the investigation of the same, as well as in the investigation of and research into the underlying principles of stream pollution, sewage treatment, water purification, and sanitary science in general. It further seems that there is a very legitimate function in the co-ordination of effort in interstate relations to a definite policy for all concerned. Regulation of the quality of water for interstate carriers might also properly be reviewed from time to time.

Suggestions for Studies.—Our opinion as to the relative prominence of different lines of study is expressed in order of importance as follows:

(1) Fundamental studies of basic problems leading to results of general application; for example, studies of analytical methods, the laws of oxygen loss and replacement, the laws covering bacterial death rates, laws governing the efficiency of filtration, the efficiency of methods of waste disposal, and the laws governing the removal of colloids, dehydration of colloids, color removal from water supplies, etc.

(2) Collective studies bringing together scattered observations; for example, assembling from various sources, material relating to stream pollution conditions, sewage treatment practice, water purification, etc., utilizing data available from State and municipal organizations.

These studies should, if possible, be correlated by enough personal contact, and perhaps laboratory work, to put the methods of reporting and analysis upon a common basis. If practicable, more effort should be made towards standardization of laboratory methods and methods of reporting. In this connection, also, might well be considerad the practicability of a semiannual review of the progress in the fields of sewage treatment, water purification, and sanitary science, with a view to making more easily available in brief compass the special work being carried on throughout the country, as well as summarizing progress in the work.

Detailed studies of individual interstate waterways might be made over a comparatively short period of time, say two or three months, with the primary object of advising the States concerned as to a uniform plan of regulation, as to policy, of both sewage treatment and water purification. An effort might be made to insure co-operation between the States in carrying out such joint projects.

We do not believe that it is properly a function of the service to co-operate with States and municipalities in studying the specific local problems not involving interstate relations. Our personal opinion is that these matters should be left to local authorities, and that such a tendency toward centralization should be avoided. Further, we believe that the practice should be avoided, so far as practicable, of detailing men to serve in States or municipal positions without expense to the State or municipality concerned. The practice of detailing men to serve when paid by the State or municipality is not so objectionable, and, under certain conditions, may be very beneficial in starting a useful line of administration.

Our general feeling is that at present, with the studies on the Potomac, Ohio and Illinois Rivers, the service will have obtained a mass of data on stream pollution which will be applicable to many conditions. We believe the next steps might well be to investigate the loading of water filtration plants in more detail than in the past, and to study the relation of sewage treatment to water purification. In this connection, standards for water supply may well be considered. A beginning in the study of the basic laws covering the chemistry and bacteriology of the treatment of water and sewage might well be made. In all this work, the investigation should be directed to work along lines leading to some practical application as well as to purely scientific research.

The Orifice in Thin Plates as a Means of Determining Discharge of Water in Small Pipes

The use of an orifice in a thin plate inserted between flanges on small pipes may frequently be used to advantage in measuring the flow of water in the pipe. This is particularly true where a weir box or other more expensive methods cannot be used. Experiments through such orifices have been made from time to time, especially those made a few years ago at the Engineering Experiment Station of the University of Illinois, and recorded in Bulletin 109 of the Experiment Station and also reviewed in Engineering and Contracting. These experiments were made on 4, 6 and 12-in. pipe. Recently, additional experiments have been made on 3 and 4-in. pipe at the hydraulic laboratory of the University of Kansas by V. L. Austin and Clarence Bennett under the supervision of Professor J. O. Jones.

The apparatus consisted of an elevated tank with a pump supplying it, measuring tank, and the pipe to be tested. The orifice in a thin plate was placed between two flanges in the pipe and at points 0.8 of the diameter above and 0.4 of the diameter below the flange, there were inserted manometer connections for measuring the loss of head. The size of the orifices used were such that the ratio between them and the diameter of the pipe for both sizes were 2, 2.66, 4 and 8. The drops in head through the orifices varied from .075 to 25 ft. The smaller heads on the 4-in. pipe were measured with a kerosene manometer and the larger with a mercury manometer. An air gage was used for the heads between these two. On the 3-in. pipe only the air and mercury were used.

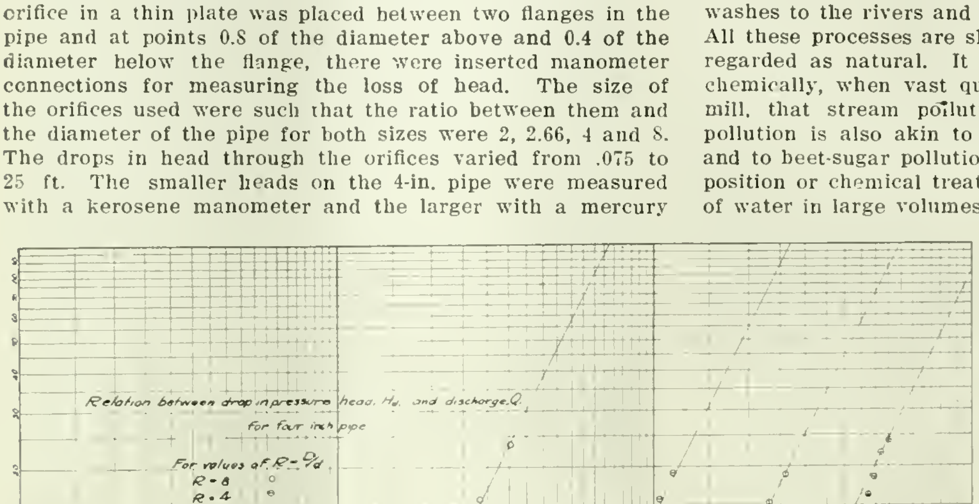

Fig. 1.—Relation Between Drop in Pressure, Head and Discharge for 4 In. Pipe.

Figures 1 and 2 show the relationship between the drop in pressure head and discharge for both sizes of pipe. All of the lines are parallel and have a slope of 2 to 1. It was also proved that, for a given drop in pressure head, the velocity is a function of the ratio of the diameter of the orifice to the diameter of the pipe.

Stream Pollution by Pulp Mill Wastes

Facts Regarding Pulp Mill Wastes and the Larger Problem of Pollution of Streams by Industrial Wastes, Discussed in Paper Presented June 21, at Annual Convention of American Society of Civil Engineers

By GEORGE C. WHIPPLE,
Professor of Sanitary Engineering, Harvard Engineering School.

It should be noted that the pollution of streams by pulp-mill wastes is only a part of a more general problem—the pollution of streams by trees and tree products—a problem which appears in many forms. Annually, the leaves fall, decay, and the products of their leaching are carried into ponds, brooks and rivers. Trees die and gradually their wood decomposes. Trees are floated down stream to the mills, and their soakage tends to increase the color of river water, although the effect is not great. Logs are sawed; the sawdust lies in heaps or washes to the rivers and the pollution takes a different form. All these processes are slow, and the resulting pollutions are regarded as natural. It is only when wood fiber is treated chemically, when vast quantities of logs are brought to one mill, that stream pollution becomes a problem. Pulp-mill pollution is also akin to that of strawboard waste pollution and to beet-sugar pollution, both of which involve the decomposition or chemical treatment of vegetable fiber and the use of water in large volumes.

Processes of Making Wood Pulp.—There are three processes of making wood pulp, which need to be distinguished from each other because of the difference in their waste products. They may be referred to as (a) ground pulp, (b) soda pulp, and (c) sulphite pulp. The object of all these processes is to separate the fibrous from the non-fibrous parts of the wood, the fibrous materials being used for making paper.

Ground pulp is made by cutting logs into short lengths and pressing them against rough grinding wheels kept wet with water. The resulting crude pulp is washed, screened, deposited as a blanket, rolled and dried. Mechanical pulp thus prepared contains not only cellulose but also lignin and resinous matter. The wash water contains a large quantity of wood fiber and extractive matter, sometimes 10 per cent of the weight of the wood. Chemically, it resembles sawdust, but is finely shredded instead of granulated.

In the soda process, soft wood, usually poplar, is chipped and digested in hot caustic soda, the resulting plup being washed, bleached, drained and worked into the usual blanket form. Soda digestion yields a soft grayish-brown pulp and a black liquor which results from the decomposition of the lignin and resins. A large part of the soda used is recovered by concentrating this black liquor in evaporators, burning off the lignin and other organic materials in rotary furnaces, leaving carbon and sodium carbonate which is leached out and converted back to caustic soda by boiling with caustic lime. As a result, there is wasted a small volume of black-ash sludge which contains a little unbleached soda ash, and a large volume of calcium carbonate sludge. A small volume of lime sludge resulting from the bleaching process is also wasted. The liquid wastes consist of wash waters from several parts of the process. They contain wood pulp, caustic soda and hypochlorites, but are usually not large in volume. In recent years, electrolytic methods of producing caustic soda and calcium hypochlorite from brine have been introduced and savings made which have reduced the waste products. It is said, however, that for every ton of wood-pulp product about 150 lb. of caustic soda are lost.

If all the solid waste products from soda pulp mills were to be discharged into the streams, a serious pollution would occur. Sedimentation basins are usually provided and with them it is possible to retain the bulk of the sludge. The volume of the sludge is very large, however, and in the course of years large areas are required. Unless the sedimentation beds are well operated, foul liquids are likely to be discharged from them, either by drainage or by overflow at times of rain. On the whole, however, the soda process, with its recovery methods, destroys a large part of the lignins and wood extractives by burning, and the pollution of streams by soda pulp mills is a mineral more than an organic pollution.

In the sulphite process, the wood fiber is disintegrated by the use of the sulphites of calcium and magnesium with an excess of free sulphurous acid. Spruce and hemlock are the woods commonly used. The sulphite is manufactured by passing sulphurous acid through a suspension of milk of lime, or by burning sulphur and passing the fumes into an acid tower packed with crushed limestone or dolomite, water being allowed to trickle down as the fumes ascend. The sulphite solution runs out at the bottom of the tower and is pumped to the digesters in which the chipped wood is packed. After digestion for several hours under high pressure, the contents are delivered into a pit from which the waste liquor drains off, leaving the fiber. This waste sulphite liquor has the appearance of a thin molasses, and has a woody, acrid, sulphurous odor. It often contains as much as 10 per cent of solid matter, consisting of wood fiber, lignin, resin and wood extractives modified by the process. It generally contains sulphurous acid, sometimes as much as 0.5 to 1 per cent. The pulp is screened, washed, and perhaps bleached, and is worked into a blanket ready for paper-making, these processes yielding waste waters which contain fiber and other impurities. It will be observed that in the sulphite process the lignin, resin and wood extractives are wasted in the stream, whereas, in the soda process, they are mostly burned. For this reason, the pollution of streams by sulphite pulp mills has proved a more serious matter than that caused by pulp mills using the soda or the mechanical process.

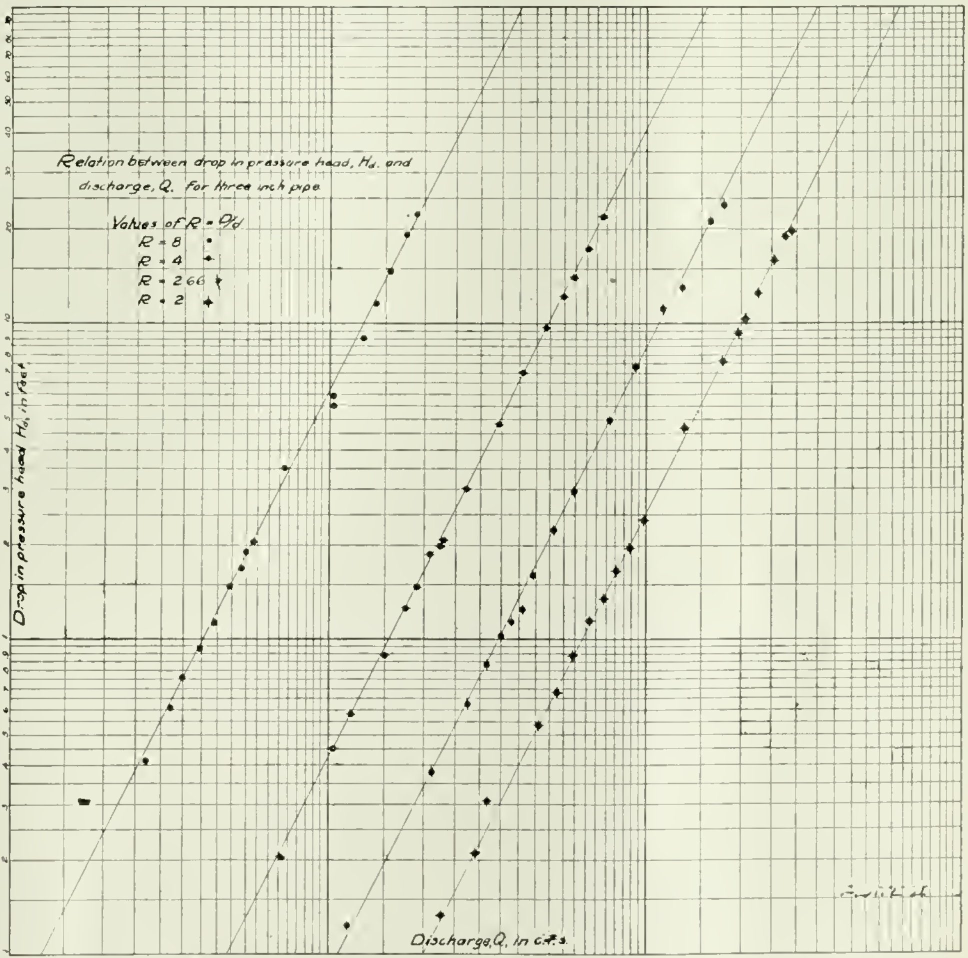

Fig. 2.—Relation Between Drop In Pressure, Head and Discharge for 3 in. Pipe.

Composition of Sulphite Liquor.—The volume of the liquid waste from a sulphite pulp mill is large and may be as much as 800 to 1,000 gal. per ton of pulp. It is said that for each ton of finished pulp an equal quantity of organic material is discharged into the stream as waste liquor, together with about 400 lb. of sulphur in acid form or organic combination. The action of the bisulphites on the lignin is to produce a mixture of sulphonated substances which give rise to lignin-sulphonic acid or the calcium of magnesia salts of this organic acid.

Earle B. Phelps has given the following average analysis of two samples of sulphite liquor, which may be regarded as typical:

	Parts per million.
Total solids	95,000
Loss on ignition (organic)	82,000
Oxygen consumed	36,000
Ash (mineral)	13,000
Analysis of ash:	
Calcium (Ca)	2,200
Magnesium (Mg)	1,200
Sulphur (S)	2,000
Free SO_2	1,000
Total sulphur (mineral and organic)	10,500

Mr. Melville C. Whipple, who analyzed a sample of waste sulphite liquor at one of the mills on the Black River, New York, found that it had an iodine absorption equivalent to 224 parts per million of SO_2.

As far as the speaker is informed, no successful method of utilizing or treating sulphite wastes has yet been devised. Its acid condition precludes the use of bacterial methods without prior neutralization and its large quantity of soluble matter makes settling processes of little avail. Evaporation, which is an expensive process, seems to be a necessary preliminary to any method of utilization. The use of detention tanks for equalizing the discharge instead of allowing heavy discharges to occur at intervals, is of some benefit but does not solve the problem. If one considers the damage done and also the value of the substances wasted, it is evident that the prevention of pollution by pulp-mill wastes is worthy of careful study by chemical engineers. Sutermeister states that, in Europe, mills have been obliged to close, because it has been impossible to purify the waste liquors sufficiently to comply with legal requirements. Attempts have been made to use the sulphite liquor as a road binder, a binder for moulding sands, a binder for powdered coal, a fertilizer, a sizing for paper, a food for cattle, a source of dyestuffs, a material for insulation and artificial leather, or a source of alcohol. The speaker has no practical suggestions to make at this time on the utilization and treatment of wastes but, instead, will discuss briefly the effect of sulphite wastes on streams.

The peculiar character of waste sulphite liquor is its sulphur content, its acidity, and its high organic content. Sulphite mills and often the villages in which they are located, reek with the characteristic odor. Sulphurous acid escapes into the air in such quantities that the water supply, used for process purposes, when exposed to the air, absorbs it, the natural alkalinity of the water being reduced to measurable amounts. Sulphur in other forms may also be absorbed by the process water, partly from the air, but even more from the pulp during the washing processes. One consequence of this is, that the troughs and channels and even the screens and washboxes in a pulp mill become coated with slime which is shown by the microscope to consist of Beggiotoa, Sphoerotilus, Leptomitus, and other fungi which require sulphur for their growth. The slime problem is often serious in pulp mills and frequent shutdowns for cleaning purposes are required. The slime becomes dislodged from the troughs and settles on the pulp blankets, making dirty spots which affect the sale of the product and sometimes require the pulp to be rewashed. A few years ago, at one of the Canadian pulp mills, the speaker experimented on the control of slime growths by the use of copper sulphate coupled with other chemical treatments, but this experimental work had to be given up on account of the World War. Sufficient was accomplished, however, to warrant the statement that the slime growth can be controlled by proper treatment.

It is a fact which is more than a mere coincidence, that these three filamentous fungi, Sphoerotilus, Beggiotoa, and Leptomitus, found in the water of pulp mills, are also found in sewage polluted waters. Together with Thiotrix and, perhaps, Saprolegnia, they appear to require sulphur and, either by choice or effect, are found in waters of low dissolved oxygen content. These fungi are often found on sticks and stones in the streams below sulphite mills, appearing as clumps or tufts of fibers, sometimes white like cotton, but more often cream-colored, gray, or salmon pink. When they decay, they blacken and become foul smelling, a condition usually associated with septicity, that is, with lack of oxygen and bacterial decomposition.

Deposits of pulp sometimes occur below sulphite mills where there is slack water. The shores often become covered not only with the fungi mentioned, but with growths of Oscillaria, the long bluish-green filaments of which enmesh the pulp. In the sunlight, bubbles of oxygen are generated, which also become enmeshed and float great masses to the surface of the water. Various animal forms take shelter in these oxygenated masses, and other algae grow on them until they become great centers of microscopic life. If there are other pulp or paper mills down stream, the quality of the water at the lower mills is likely to be seriously impaired for washing purposes. These growths can be kept down by the proper application of copper sulphate.

Effect of Discharging Sulphite Wastes Into Rivers.—The practical effect of discharging sulphite wastes into rivers depends on the various factors already mentioned. One effect is to make the stream unsightly by reason of deposits of pulp and fungi and the algae growths just mentioned, and if a stream once becomes foul in this way, it tends to become a catch-all for many kinds of débris and filth. Uncleanliness is contagious. M. O. Leighton* described the effect of the pollution of Ausable River with sulphite wastes for a distance of 20 miles, and even into Lake Champlain. He also described the pollution of Bouquet River with soda pulp wastes. Some thought at one time that it increased the algae growths in the lake, but this was never definitely proved. Phelps† has also written on the general subject of sulphite pulp wastes and described processes and proposed methods of treatment.

Pulp-waste pollution tends to drive away fish. The fine pulp gets into their gills and the sulphite pollution may kill them by exhausting the dissolved oxygen. The New York Conservation Commission has recently assembled data showing the tolerance of certain fish to industrial wastes and among them are the following: Bass, perch, and trout were killed in about 1 day by sulphite wastes diluted 10 to 1 and when diluted 75 or 100 to 1 trout fry and bass were killed in several days. Dilutions of 100, 200 and 500 to 1 did not kill perch in several days. That death was due to suffocation rather than poisoning was indicated by the fact that a 50 to 1 dilution of the sulphite liquor artificially aerated did not kill perch or bass in 29 days. Bleach sludge diluted 500 to 1 failed to kill perch in 14 days, and aerated bleach sludge diluted 400 to 1 did not kill perch in 5 days. Even if the dilutions are far greater than these figures, sulphite wastes may tend to drive away certain kinds of fish which, like trout and salmon, apparently seek pure waters. There can be no doubt that there are selective differences among fish as to oxygen requirements. It is said that certain of the grosser fish are capable of tolerating pulp-mill wastes, but acquire disagreeable tastes which make them non-edible.

Effect of Wastes on Water Supplies.—Sulphite wastes may also injure the water of a stream in its use as a boiler water. In at least one instance, such wastes have been known to make the water of a large stream acid, and the damage done by them is often more subtle than that produced by the gross pollution in the vicinity of the mill. The salts of lignin-sulphonic acid, or whatever the compounds may be which result from the action of the acid bisulphite on the lignous and resinous compounds of the wood, have a most persistent odor; even when the sulphite wastes are greatly diluted, it can still be recognized. Formerly, the water supply of Augusta, Me.,‡ was taken from the Kennebec River, and the imperfectly filtered water often had a noticeable taste and odor resulting from the pulp-mill wastes at Winslow, 17 miles up stream. The water supply of Bangor, Me., is taken from the Penobscot River, and before filtration has the same characteristic taste. At times, the alkalinity is materially reduced and the coagulation of the water rendered difficult. At Watertown, N. Y., the Black River, polluted by sulphite wastes at Deferiet, Herrings, Carthage and Lyons Falls, has the same taste and odor, which the filter has never been able wholly to remove. The odor is not removed by aeration and the use of chlorine seems at times to intensify it. The municipal authorities of Augusta wisely abandoned the Kennebec River supply and substituted a supply from a pond not far away. At Bangor, in spite of advice to seek another source, the Penobscot supply has been retained and improvements made in the filter plant.

Unfortunately, it is not the odor alone which causes trouble with downstream water supplies. The sulpho-lignous organic matter interferes with the coagulation of the water, reducing the efficiency and increasing the cost of filtration. The exact nature of the reactions has not yet been accurately worked out, but some studies have been made at the Watertown filter, which have led to modifications in the process and improvements in the results.

Studies at Watertown Filters.—The water of the Black River is deeply stained, its average color being about 80 and its maximum color in different years running up to 135. The quantity of carbonaceous organic matter in the water is greater than that represented by the color. In a discussion§ by the speaker before the Society in 1901, on decolorization of water, it was shown that in stained waters the organic matter, as indicated by the "oxygen consumed" test, was 0.125 part per million for each unit of color; but, at Watertown, tests have shown that the oxygen consumed corresponding to a unit of color is often double this quantity. The oxygen consumed is also higher at seasons of low stream flow, when the dilution is less than at other times. Some of the colorless organic matter found at Watertown may be due to sewage pollution, but inasmuch as sulphite waste shows a high figure for oxygen consumed, it is reasonable to suppose that these wastes are an important factor in the Black River. There are visible evidences of this pollution at the Watertown filter, as particles of woody fiber from the waste pulp can be easily detected by the eye; in fact, the superintendent of the filter is in the habit of making a daily record of the approximate quantity of pulp observed in the raw water. Phelps has shown that the "oxygen consumed" in sulphite waste liquor is from 36,000 to 60,000 parts per million; therefore, even after being diluted several thousand times, the water would contain as much organic matter, measured in terms of "oxygen consumed," as would correspond to a color of 100 units. It has been found, as a result of filtration experience, that the quantities of alum required for the coagulation of unstored colored waters free from sewage and industrial wastes, ordinarily bear a fairly definite relation to the color of the water; but in the case of the Black River water, the quantity of alum required is relatively great, largely because of the organic matter from the sulphite wastes. When the water filters were designed by Allen Hazen, in 1903, it was decided, as a result of experiments made with colored waters, that a period of coagulation of 4 hours would be required, a time considerably longer than previous practice. Experience, however, has proved that even this was not long enough. In 1917, an existing settling basin was converted into a coagulation basin which increased the period of coagulation to about 8 days, and the results of this longer period have proved to be beneficial. Better results have been obtained, although the quantity of alum used has not been lessened. It will be seen, therefore, that, in various ways, sulphite waste pollution increases the cost of water purification.

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*"On the Pollution of Lake Champlain," Water Supply and Irrigation Paper, No. 121, U. S. Geological Survey, 1905.

†"The Pollution of Streams by Sulphite Pulp Wastes," Water Supply and Irrigation Paper, No. 226, U. S. Geological Survey, 1909.

‡"Quality of the Kennebec River Water," Water Supply and Irrigation Paper, No. 198, U. S. Geological Survey, 1907.

This is not the whole story, however. Unless coagulation is well accomplished, that is, unless enough alum is used and the time of coagulation is sufficiently long, some of the alum in combination with the organic matter will pass through the filter. Three objectionable results follow, namely, the filtered water retains some of the "pulp-mill taste"; the water when heated for ordinary domestic service becomes corrosive, attacks iron, and causes red-water troubles; and the bacterial removal by filtration is not complete. These are all serious matters. Even with what is regarded as good coagulation, the sulphite taste may persist in filtered water.

At one time, as a result of experiments at Watertown, it was thought that basic alum was generally preferable to acid alum for water-filtration purposes. Later studies have made this doubtful. There are, perhaps, times when an acid alum may give better results than a basic alum, waters differ in this respect. With alum made at the filtration plant, as is now often the case, it may be possible to modify its character so as to obtain the best results for any particular water.

Engineers once thought that they had obtained a fairly complete understanding of this problem of coagulation, but experience with mechanical filters, although on the whole successful, has shown that there are many things to learn about coagulation, especially the coagulation of soft, colored waters and waters polluted with such wastes as those from pulp mills. The nature of the colloidal substances, the possible protective effect of colloids on bacteria, the relations between chlorine and organic matter, and the reaction between sulphate of alumina and organic colloids, are some of the subjects which chemists and biologists now have under consideration.

Enough has been said, perhaps, to show that the pollution of streams by pulp-mill wastes is a matter which may cause damage to down-stream riparian owners and affect the health and comfort of many people in communities which take their public water supply from polluted rivers. It also has a bearing on the general problem of conservation of natural resources. Pulp mills not only spoil the rivers, but they despoil the forests. Wood pulp is a useful substance, but there is hardly any raw material that is wasted so lavishly. Without doubt, chemical engineers can solve the pulp-mill pollution problem if capitalists will provide the means, the laws are ample to protect the down-stream riparian owners if they are enforced but, in the speaker's opinion, a better solution of the problem lies in preventive measures, that is, in measures which will protect the forests. Conservation demands that tree trunks suitable for lumber be used for that purpose. It is necessary to find methods of obtaining cellulose such that the newspaper which is in use a day and the paper towel which serves the purpose of a moment are not made at the expense of a tree which has taken 25 years to grow.

Apparent Indifference to Stream Pollution.—The speaker may be wrong, but it appears to him that there is now a greater indifference to stream pollution, a greater laxity in enforcing laws, than was the case before the World War. Probably this is merely a part of the widespread lapse from law and order unfortunately so prevalent at this time. It is a condition which must not be allowed to continue. The pendulum may swing, perhaps, from too much laxity to too much rigidity. The present is a good time, therefore, to consider carefully in a broad spirit of co-operation and in a scientific manner, the best way of dealing with the whole subject of stream pollution. Certain things have been demonstrated by experience. The pollution of a stream may steadily increase without serious offense and without attracting much attention, until suddenly a crisis is reached, the dissolved oxygen disappears from the water and the river is wrecked. It has been learned that it is cheaper and safer to protect a down-stream water supply by filtration than by up-stream treatment of sewage, but that a single line of defense is not enough. It has been learned that many kinds of manufacturing wastes impart tastes and odors to waters, which cannot be readily removed by water filtration and that chlorination sometimes accentuates them, and that these tastes and odors may be produced even when the polluting substances are very dilute. It has been learned that river-pollution problems are not all related to the public health. It has been learned that because rivers flow between states and from one state into another, the control of pollution by independent state action is not adequate to meet the situation, and yet the police power resides in the sovereign states. It is evident that some new mode of procedure is necessary to deal with the situation; yet it is doubtful whether any better legal remedies will ever be devised than the application of the principles of common law and the exercise of police power by the separate states. The speaker does not favor delegation of the police power to the Federal Government in this matter, and at present the powers of the Federal Government are limited to navigable streams.

A uniform policy throughout the country is much needed. To secure this, a thorough scientific, economic and legal study of the whole subject of stream pollution should be made on a national scale by a joint committee representing the national bodies interested in the different phases of the subject, under the sponsorship of one of the Federal departments with congressional authority and an adequate appropriation. This committee, after several years of investigation, should formulate a policy, suggest model laws, and recommend their adoption by the several states. It may be possible to organize river districts independent of state boundaries, with commissioners whose duties would be to secure co-operative efforts to keep the rivers clean and to utilize the waters of the streams to the best advantage of all the people living within the districts, leaving all legal actions where they now are and where, in the interest of good government, they should remain. The whole subject at present is in a chaotic state. Some state departments of health attempt to exercise almost despotic powers over the streams; in other states, their action is chiefly advisory; and, in some sates, there are pollution commissions independent of the health authorities. Although there has been a recent laxity in law enforcement, it is hoped that the next move will not be toward a too arbitrary enforcement of ill-considered laws, but that means will be found to accomplish by co-operative effort what is so difficult to accomplish by law. It would appear that the society is one of the organizations which should take the lead in this important matter of conservation.

Employment of Engineers Continues Strong

Reports from more than 200 separate localities to the Employment Department of the American Association of Engineers show little trace of unemployment among professional engineers. Most reports mention a scarcity of men for engineering work, particularly for the building field.

Work is picking up in the mining region in the Southwest and companies are planning extentions and additions. Around Salt Lake City practically all engineers are employed, and if any additional work is to be undertaken men from other localities must be engaged. Similar conditions exist in California and Oregon, with a tendency toward higher remunerations. Employment in Eastern cities is quiet owing to a scarcity of coal in industry and transportation facilities; several plants in New York and other cities are contemplating shutting down. North Carolina reports one of the most extensive highway projects that has been undertaken by any state. Many requests are received for mining engineers for Illinois, Indiana and Kentucky coal fields where labor conditions have recently been settled. Only a few requests have been received for chemical engineers.

The following table shows the trend of employment covering all sections of the country and all work done by the Association during June and July, 1922, as compared with July, 1921.

	July. 1922.	June. 1922.	July. 1921.
Applicants for employment	1,484	1,456	2,215
Positions received	413	433	321
Men referred	1,433	1,462	2,567
Men placed	206	225	212

While fear is expressed from certain quarters of less construction and manufacturing activities due to car shortage, transportation difficulties and coal scarcity, the employment situation in general continues good.

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§Transactions, Am. Soc. C. E., Vol. XLVI (1901), p. 111.

Laboratory Control at Illinois Water Purification Plants

Some interesting points on the above subject were brought out by M. Warren Cowles, Assistant Engineer, Illinois State Department of Public Health, in a paper on "Water Purification Plant Operation and Analytical Control," presented at the recent convention of the Illinois Section of the American Waterworks Association. An abstract of that portion of his paper relating to analytical control follows:

It is now generally agreed, by those who have studied water purification plants, that careful and continuous analytical control is necessary if an effluent of proper physical appearance and sanitary quality is to be available at all times, and if the plant is to be operated economically. A purification plant is not being properly operated if water which is not of satisfactory appearance is being delivered at any time and certainly is not entitled to as high a rating as a plant which gives an effluent of satisfactory appearance at all times. The same is true of the sanitary quality.

Two General Groups of Laboratory Control.—Laboratory control can be divided into two general groups: (1) control of the purification processes by periodic analyses made by the State Health Department; and (2) control by analyses made locally either by non-technical filter operators or by technical operators or chemists or bacteriologists. At one time the former method was believed to be fairly satisfactory, but in the past few years it has become increasingly evident to all persons concerned with water-purification processes that each plant must be regarded as a separate entity and that operating conditions are not the same at any two plants. The State Health Department may make periodic analyses to check the operation of the plants, but continuous satisfactory operation cannot possibly be expected unless some daily tests are made at the plant.

In the Province of Quebec, samples of gas formers are collected and inoculated into lactose broth daily at each of the water-purification plants and mailed to the central laboratory at Quebec for examination, and through the results of these tests, it is presumed that the purification plants can be properly operated. It is believed that such a system, if pursued too far, is not satisfactory, in that it tends to remove or lessen initiative on the part of the purification-plant operators, also to reduce or negative the factor of personal pride and responsibility and to substitute governmental paternalism.

One of the principal objections against local laboratory control, namely, the expense has been largely removed since pressure cookers for home use built in a manner similar to the steam autoclaves can be obtained now at price of from $15 to $25. A horizontal steam autoclave of satisfactory design varies from $110 to $250, and an Arnold sterilizer requiring three successive days for sterilizing culture media is as inconvenient as the steam autoclave was expensive. Small incubators made of wood, lined with non-conducting material such as transite or asbestos wood can be obtained for $15 to $30, or a small egg incubator can be used with a kerosene lamp, providing the fumes from the lamp do not enter the incubation chamber. If electricity is available, heating units complete with thermostatic control may be purchased for about $12, or a home-made device consisting of carbon lamps with a "Mesco" thermostat can be obtained for $2 or $3.

The Illinois Division of Engineering and Sanitation has prepared a list of apparatus required for the control of sterilizing processes, including bacteriological and ortho-tolidin tests, the cost of which complete with steam pressure cooker and incubator would not exceed $150. For filtration plants, an expenditure of $20 to $30 additional would cover the apparatus needed for the other purely chemical tests.

It is desirable that wherever possible the services of a trained sanitary engineer, chemist, or bacteriologist, be made available not only for water-purification plant control but for other work of a public health nature in a community. In the smaller plants, this is generally out of the question, but in many instances the science instructors at the high schools might be engaged to do such work. Several plants are now planning to install laboratory control, tests to be made by one of the officials of the water company or by some person under their direction.

The State Department of Health considers tests for control of a complete purification plant should include turbidity, alkalinity to methyl orange, bacterial counts on agar at 3.7°; gas formers in 10, 1.0, and 0.1-cc. portions, and tests for free chlorine, by use of ortho-tolidin. Tests should be made on the raw, the filtered, and the filtered water after sterilization. Special conditions at individual plants may govern the proper location of sampling points.

It is believed that additional information concerning the efficiency of the various stages of the purification may be obtained by the use of the 20-degree count on agar, by the determination of color (where of importance), and by chemical or physical tests to determine the effect of alum solution or other material used as the coagulant.

Hydrogen-Ion Concentration.—Recent developments in the study of hydrogen-ion concentration of various waters have pointed strongly to the further necessity of adequate local control of these processes, and is apparently pointing the way to the solution of many of the difficulties which now occur in purification plants, especially where chemicals are used for coagulation purposes. At the Montobello plant at Baltimore, Md., this test has proven of decided value in controlling corrosion. These determinations are being made at only one plant in Illinois, namely, Mt. Vernon, under the direction of W. F. Monfort, consulting chemist, St. Louis, and it is hoped that at a later date he will present some of this information at one of our meetings.

It is suggested that if these Ph. values are to be of any value, that the standards must be prepared by properly qualified persons provided with properly calibrated apparatus, and a proper grade of chemicals, and that samples for comparison with these standards must be properly collected and compared with proper standards, otherwise the results may be valueless. Standards are now on the market which can be expected to remain reasonably accurate for a period of at least six months if kept at an even temperature unexposed to daylight, and sometimes longer, but they should be checked from time to time.

Just a word of caution to persons making their own culture media. It must be made from satisfactory constituents, properly and carefully prepared, otherwise the results may not be comparable with those obtained from other laboratories. The dehydrated culture media now on the market seems to be satisfactory at least for lactose broth and plain agar, but some of the media containing dyes frequently does not give satisfaction.

Laboratory Control at Illinois Plants.—There are 17 plants maintaining records of the purification processes, but only 11 of these have what may be considered adequate laboratory control. At 14 other plants, there is a partial control. Ortho-tolidin tests are used at 21 plants.

Of the 17 sterilization plants, Chicago, Aurora, Freeport and Peoria have complete laboratory control, and 12 have only such control as may be afforded by ortho-tolidin tests, checked from time to time by the results of bacteriological examinations of the water by the State Department of Health.

Forms are now in preparation by the Illinois State Department of Health for a more complete report than that now furnished by some of the plants. The forms for filter plants will consist of a monthly sheet to contain results of daily analyses and other daily operating data, and a yearly summary sheet. The forms for plants comprising chlorinating equipment only will be similar but with a smaller amount of data and are to be furnished weekly together with a monthly summary. It is intended that these record forms will be such as to give information which the State Department of Health regards as essential and also data which are of local importance, either to the municipality or to the filter company operating the plant, and will not be burdensome to maintain. Some of the States, among which are Ohio, New York, Pennsylvania and California, have required records of this kind for some time, and this information, together with results of periodic control analyses and inspections of the plants at least once in six months have shown that much can be accomplished by this close and active co-operation.

Tests of Filter Sand at Cincinnati, O., Purification Plant.—The report of the Cincinnati Water Department for the years 1919-21 contains the following: Tests upon the filter sand in 1920 showed an effective size of 0.39 mm. and a uniformity coefficient of 1.21, as compared with 0.34 and 1.60, respectively, when the plant started operation in 1907. At this rate of growth, the sand will remain an excellent filtering medium for many years to come.

Closing 42 In. Outlet Pipes in Shoshone Dam Under 200 Feet of Water, with Wooden Balls*

BY J. S. LONGWELL.

Project Manager, Shoshone Irrigation Project of U. S. Reclamation Service.

The Shoshone hydroelectric power plant, now under construction, is located in the Shoshone River Canyon, a short distance below the Shoshone Dam, 8 miles west of Cody, Wyo.

The Shoshone Dam, which forms the storage reservoir for the lands of the Shoshone project is a rubble concrete arch, 328 feet high, 200 feet long and on the crest, 108 feet thick at the base and 10 feet thick at the crest. The height above river bed is approximately 233 feet. At the elevation of the spillway, 10 feet below the crest of the dam, the storage capacity of the reservoir is 456,600 acre-feet. The dam was completed in 1910.

The plant is to obtain water through a penstock connected with the reservoir, and the head on the plant will therefore depend on the height of water in the reservoir and will vary from 100 to 240 feet. As now planned, the ultimate capacity of the plant will be approximately 5,400 H. P. at 140-foot head and will consist of three units, two of 1,100 H. P. and one of 3,200 H. P. The building is being built for final development, but only the two 1,100 H. P. units will be installed at the present time. The plant is being constructed primarily for supplying electric energy for the operation of excavating equipment on drainage and canal construction and for the operation of construction plants in connection with future extensions of the project. Incidental to this use for construction, power will also be supplied to the various towns on the project and in the vicinity of the project.

Water is to be taken from the reservoir through the two 42-in. pipes located in the dam—at stream bed elevation—installed at the time of constructing the dam. Two 48-in. mechanically operated balanced valves for emergency use will be located at the outlet of the present 42-inch pipes. These valves will connect to two riveted steel penstocks which immediately after leaving the valves swing to the left and enter a tunnel in the canyon wall. The pipes extend about 50 ft. into the tunnel, where they connect to two 60-in. semisteel tunnel linings 10 ft. long, embedded in concrete. From the two tunnel linings there is a concrete transition 10 ft. in length to the concrete-lined tunnel section. The tunnel proper is an 8-ft. 6-in. horseshoe section and has a length of 424 feet. At its lower end is located a concrete transition, 10 ft. long, connecting the horseshoe section to a 96-inch semisteel tunnel lining. The semisteel tunnel lining is 10 ft. long and incased in concrete. A 96-in. riveted steel pipe connects to the tunnel lining and extends about 50 ft. to the lower portal, where it swings to the left and enters the power house. Outlets are provided in the pipe to furnish water to the three units. The pipe decreases in size in going through the power house from 96 ins. to 48 ins. From the downstream wall of the building the pipe swings to the right and extends about 50 ft. to the by-pass valve house, where the pipe connects with a 42-in. motor-operated gate valve, which valve in turn connects to a 36-in. hydraulically operated balanced needle valve. The needle valve is set on an angle of 13½° with the horizontal and will discharge directly into a short tunnel, the outlet end of which tunnel is below water surface in the river. This manner of discharge is to prevent spray, which would result were the by-pass discharged directly into the river.

The 42-In. Pipes Through Dam.—The two lines of 42-in. cast-iron pipe through the dam were originally controlled by two 30-in. gate valves on each line of pipe located in a gate house on a concrete bracket at the downstream face of the dam. Trouble was, however, experienced in operating these valves, and shortly after their installation both valves were torn off the south pipe and the lower one torn off the north pipe. At the time the valves were torn off the water also destroyed the lower portions of the gate house.

At the time work was commenced on the power plant the south pipe was discharging free and there was a small flow through the north pipe, as the one remaining valve was not entirely closed.

The cast-iron pipes through the dam have bell and spigot connections, except the next to the last sections which were flanged on the downstream end and the last sections which were flanged on both ends. These pipes are located on radial lines through the dam. To make the connection between the pipe in the dam and the valves, the last sections of both 42-in. pipes have been removed and replaced with semisteel pipes expanding from 42 ins. in diameter at the upper end to 48 ins. in diameter at the lower end. The 48-in. emergency valves are connected at the lower end. These pipes are so designed as to bring the valves parallel instead of on radial lines.

In order to remove the two sections of 42-in. pipe in the dam, install the new pipe and valves and make the connection with the tunnel, it was necessary to shut off the flow of water through both 42-in. pipes. There are two sets of vertical grooves or guides in the concrete at the inlet end of the pipes. In one set of grooves, in front of each pipe, there were placed structural steel trash racks. The other set of grooves was for placing stop planks, in order to cut off flow through the pipes after emptying the reservoir.

At the time it was decided to construct the power plant the water surface in the reservoir was at elevation 5,360, representing a storage of 456,600 acre-feet and a depth over the 42-in. pipes of 226 ft. To empty the reservoir through the two 58-in. Ensign balanced valves in the south outlet tunnel would have required about three months and might have resulted in a water shortage in the spring of 1922. Further complications might have developed in the nature of damage claims on account of turning out more than the natural flow and causing overflow in the lower reaches of the river. On account of these conditions it was decided to remove the trash racks under more than 200 ft. of water by grappling them with hooks and to plug the inlet end of the 42-in. pipes with wooden balls filled with concrete.

Removal of Trash Racks.—A 1½-in. cableway was erected across the canyon above the dam, a short distance upstream from the inlet to the pipes. Heavy hooks made from 1½-in. steel, consisting of two V-shaped bars with hooks at the points, bolted back to back, thus giving four hooks, were constructed for use in grappling the racks. The first effort to remove the racks was made in the latter part of December, 1920. The hooks were lowered from the cableway in front of the south pipe. No trouble was experienced, in hooking the rack, but although pulling with a 30-H. P. hoist engine through a 9-part line attached to the cableway and with the cableway stressed beyond the safe load, we were unable to remove the rack. The hook was disengaged frequently and the rack hooked again in a different place in an effort to loosen it and to try to locate the proper place for pulling. After breaking several hooks larger steel was used, and from time to time the size was increased until the last ones used were made from 3-in. material. Several cables were broken between the hook and the block on the 9-part tackle and a number of hooks lost.

After the failure of continued efforts to remove this rack with the cableway, a barge was constructed, designed to withstand a 50-ton pull with jacks. The cable was brought up through a pipe in the center of the barge. It was planned to use this barge and the cableway at the same time pulling with two lines.

While the barge was being constructed the carriage of the cableway was moved over, the hook lowered, and the north rack engaged. After persistent effort and the breaking of several hooks, the north trash rack was raised approximately 10 ft. and the hook disengaged. The depth of water at that time—Jan. 20, 1921—was 200 ft.

After raising the rack in front of the north pipe we hooked onto the south rack pulling with both the cableway and the jacks on the barge, but repeatedly broke the heavy steel hooks without moving the trash rack. Finally, on Jan. 30, 1921, after breaking a hook by pulling with the jacks on the barge, we hooked onto the rack, using the hook from the cableway, with a 9-part line and succeeded in raising the screen the proper distance. Apparently in previous efforts we had not been able to hook the rack at the proper place to enable us to pull it up in the guides. The discharge through the south pipe at the time of removing the rack was 630 second-feet and the head on the pipe 198 ft.

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*From The Reclamation Record.

Placing Wooden Balls in Pipes.—Having removed the racks, large wooden balls were constructed for use in closing the pipes. These balls were 5 ft. 6 in. in diameter and consisted of a wooden shell, well bolted, filled with concrete. They were designed to fit into the bell-mouthed pipe inlets and their weight was approximately 6,200 lbs.

One of the balls was covered with canvas about 1 in. thick and lowered on the cableway a short distance in front of the south pipe, the cable being pulled out to keep the ball away from the inlet. When the ball had been lowered to about the level of the inlet the cable was released and the ball was carried by the current into the pipe inlet. The depth of water was, on this date—Feb. 3, 1921—197 feet, and the discharge through the south pipe 630 second-feet. The ball caught in the current and went into the pipe entrance with such force that the impact could be felt on top of the dam. An examination at the outlet end of the pipes, although submerged, showed that an effective closure had been made, as there was apparently very little leakage around the ball. Later, after the cofferdam below the pipe outlets had been pumped out, we found the leakage through this pipe to be a little over 1 second-foot. This leakage, as was found from an examination of the ball from the inside of the pipe, was caused by a crushing of the timbers in one or two places when the ball hit the dam.

After closing the south pipe a second ball was lowered to effect a closure of the north pipe. The ball, however, would not go into place, and it was assumed that there was not sufficient flow through the pipe and remaining valve —partially open—to pull the ball into the inlet. The ball was raised and an effort was made to open the valve and increase the flow; the stem had, however, apparently been broken loose from the gate and it could not be opened. A charge of dynamite was then placed in the valve and the valve shot off. This allowed the pipe to discharge free under reservoir pressure.

The north pipe now being open, the ball was lowered again. The ball pulled in against the dam and materially reduced the flow through the pipe to what was estimated as 75 second-feet. A pull was made with the cable to try and effect a more satisfactory closure. Instead of stopping the flow, however, it was increased to about the same amount that was discharging before the ball was lowered. A second pull was then made with the cableway and both cables fastened to the ball and the line from the cableway came up, leaving the ball in the bottom of the reservoir. One of the cables fastened to the ball was torn in two; the other was looped as fastened to the ball. Investigation with hooks on the line from the cableway indicated that the trash rack was again down in front of the opening. It appears that the ball must have come in contact with the trash rack and caused it to slide back in place. The ball resting against the rack probably reduced the flow as observed and the first pull on the ball probably slid it up on the screen, increasing the flow. The cable may have been cut when the ball hit the screen or torn in sliding on the screen. The rods to which the cable was fastened projected a short distance from the periphery of the ball, and it seems very probable that these rods came in contact with the rack, were broken off and allowed the other cable fastened to the ball to become loose with the second pull on the ball.

After losing the ball, sharp-pointed hooks were lowered and an effort was made to hook the ball and roll it to one side. No success was attained from this method. A large net made of cable and iron rods was then constructed and lowered from the 9-line tackle on the cableway. After several days' work the ball was apparently caught, but the cable broke in attempting to raise the ball. A hook was then lowered, the net caught, pulled loose from the ball, and raised to the surface. An examination showed that the net had doubtless been in contact with the ball, as pieces of canvas and wood were found on the cable and irons of the net. A new net was then made and with new and heavier cable on the line from the cableway the net was lowered again for catching the ball. Several days were spent in fishing for the ball and finally it was caught, but we were unable to loosen it from the rack. Several charges of dynamite were exploded near the ball and then on March 16, 1921, pulling with the hoist engine through a 9-part line fastened to the cableway and a 5-part line attached to the parapet wall of the dam, the ball was loosened and raised to the surface. The depth of water at this time was 189 ft.

By the use of the hooks again, the north trash rack was caught and on March 23, 1921, it was pulled completely out of the guides and brought to the surface.

A third ball of different design as regards bolts for connection to the cable was now constructed. In this case there were no projecting rods, instead a U bolt was used, the top of which was practically flush with the periphery of the ball. This ball was filled with concrete, covered with canvas, and then lowered in front of the north pipe. The ball, however, would not go into the pipe, although the discharge through the pipe was over 600 second-feet, so it was brought back to the surface. Hooks were again lowered and an effort made to determine what sort of an obstruction was holding the ball away from the pipe. We were able to hook onto something, but could raise it but a short distance when it would slip off the hooks. Several hooks were broken in this work. On April 2, 1921, after having caught some obstruction and raised it a few feet and then lost it, observers noted that the flow through the pipe had increased. Examination of the automatic gage at the rating station below showed that the flow had increased some 30 second-feet. It was assumed that the obstruction had been removed and a box as large as would pass through the pipe was lowered, filled with rock. It passed through the pipe and it was apparent that now everything was clear. On April 3, 1921, the ball was again lowered, the current pulled it into the opening and it seated immediately. The flow through the pipe was cut off so that no motion could be detected at the outlet. Later, after pumping out the cofferdam, the leakage around the ball was found to be slightly less than 1 second-foot.

The closure of the two pipes through the dam per mitted work to be commenced on the construction of a cofferdam below the outlet of the pipes. After the valves are installed and the connections made with the tunnel, the valves will be closed. The pressure will then be allowed to build up in the pipes until there is no head on the balls, at which time they will be removed. The balls are now fastened to the parapet wall on the dam by means of 1-in. cable.

R. V. Sass is superintendent of construction on the power plant; H. F. McPhail is assistant engineer; and Michael Wagner was foreman on the work in connection with the closure of the pipes.

Occupational Index of Engineering Positions

The procedure in gathering, compiling and studying data relating to the engineering profession for the purpose of preparing an occupational index of engineering positions has been outlined in the first report of the Committee on Classification of Engineering Positions recently appointed by the American Association of Engineers. This committee consists of A. B. McDaniel, educational specialist in the War Department, chairman; C. R. Mann, Civilian Advisory Board, General Staff, War Department; Professor C. J. Tilden, Yale University; J. R. Randall, president, Rochester Mechanics Institute; and W. C. Bolin, pilot engineer, B. & O. R. R., Baltimore, Md.; E. O. Griffenhagen, J. L. Jacobs of Chicago and Professor H. H. Stock of the University of Illinois are advisory members of the committee.

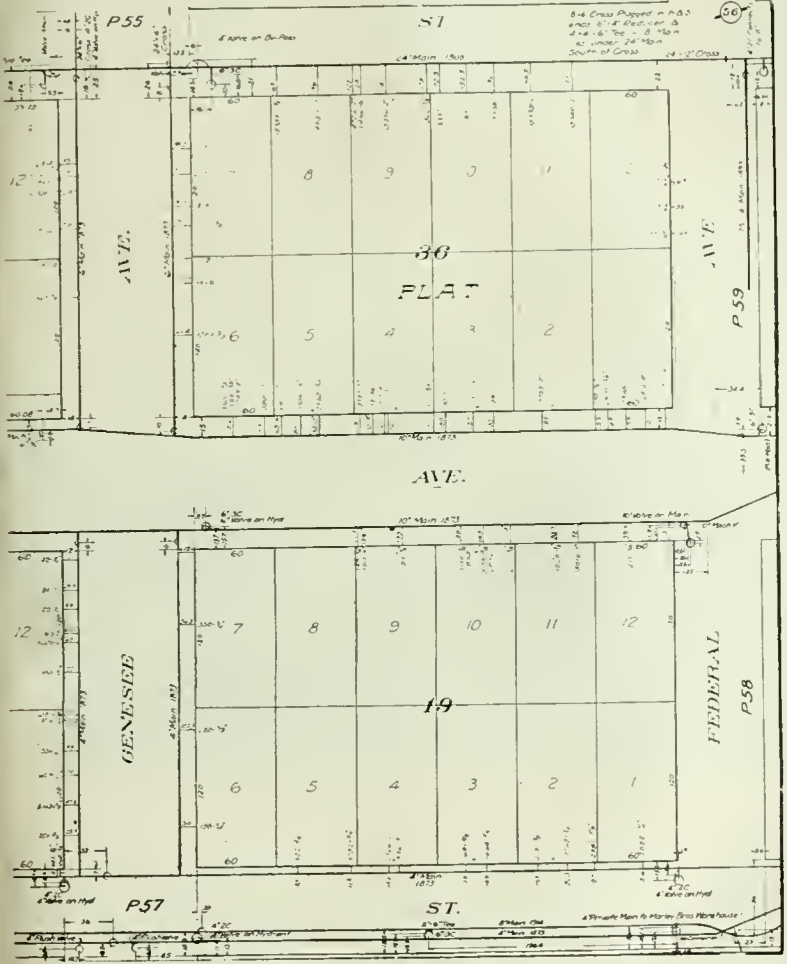
The program of the committee includes (1) the preparation of sample specifications to send out with occupational study sheets; (2) preparation of blank occupational study sheets; (3) sending out of occupational study sheets and sample specifications to at least 50 practicing engineers in each position to be studied with the request that the information indicated by the study sheet be promptly furnished; (4) the compilation of data received; (5) the preparation of preliminary specifications for publication and criticism by members of the profession; (6) a study of the criticisms received and preparation of provisions to complete such specifications.

The field of highway engineering has been selected for the first study by this committee. In this field, Prof. C. J. Tilden during the past summer, while engaged as consulting expert of the U. S. Bureau of Public Roads, has obtained a large amount of valuable data relating to highway engineering positions.

How Saginaw, Mich., Keeps Underground Records of Its Water System

The very complete record of mains, valves, hydrants, service connections, etc., a very small portion of which is reproduced herewith, was established several years ago by Mr. R. F. Johnson, at that time superintendent of Water Works, Saginaw, Mich.—now Commissioner of Light, Water and Sewers in the same city.

The map record consists of about 700 sheets bound in 14 volumes of about 50 sheets each and fully indexed. The scale of the maps is 40 ft. to 1 in. All sheets are 18 in. by 24 in. The material is "Paragon" cloth-backed paper. The size and exact position of every main, value, hydrant and service connection is shown, together with the length of service, year in which each main was laid, location of values and such additional information as is deemed advisable.



Portion of Record Showing Location of Mains, Valves, Hydrants, Service Connections, Etc.

Blocks and lots are marked with medium weight, black lines. Mains are drawn in heavy red; services in light red. Valves are marked with blue circles and fire hydrants with green circles. Data pertaining to service connections are printed in red, all other letters and figures being black. All distances are given in feet and tenths of feet.

Distances of mains and values from property lines are very carefully indicated by black figures and arrows. The size and number of connections on each fire hydrant are stated, and the size of valves wherever it might be in question, as on hydrant connection.

The water system covered in the underground records takes in 17 square miles of territory, and includes 155 miles of mains, 1,342 hydrants, 1,362 valves in mains and 13,000 service connections.

It cost $7,500 to prepare the underground record, and it costs about $1,200 per year to keep it up to date, this figure including the necessary auxiliary books of valve locations, etc., for the distribution among foremen and city engineer's force.

Construction of Driven Wells

Some interesting information on pumping with the air lift was given by Mr. John Oliphant, Chief Engineer, Pneumatic Pumping Department, Sullivan Machinery Co., Chicago, in a paper presented at the last annual convention of the American Waterworks Association. That portion of the paper relating to the driving of the wells is given below.

It is very rare for the pumping engineer to find a complete record or log of a well—while perhaps the wells are the most important thing about a municipal or industrial plant, the contract for the work seems to be let in a haphazard manner and no record required from the driller as to what class of material be penetrated—where it was located, and its thickness, to say nothing of the kind and size of casing and strainers used. It is no uncommon thing to go into a well that has been represented to be of a certain size, to the bottom, and find it has been reduced, sometimes more than once. This entails considerable loss of time and expense to secure equipment that will go into the hole.

A driller should be required to furnish a complete log and this should be as carefully preserved as the deed to the property.

Well in Sand or Sand and Gravel Formation.—The standard practice of well drillers is to equip gravel and sand wells with a strainer, designed to shut out the sand from the working barrel of a deep well pump. In time, these strainers become clogged with sand and the flow into the well is thus reduced. By a system of back-blowing, the output from such wells can be permanently increased.

The correct strainer for wells of this class, pumped by the air lift, is a perforated screen with openings of a suitable size to admit the fine material into the well, from which it can be pumped, and to hold back the coarser particles, so as to form a natural gravel filter bed outside of the artificial one.

The force available for getting water into a well is the head, due to the difference between the static level in the water strata outside the well, and the pumping level in the well, minus friction due to the strata and screen. Therefore, the more this friction can be reduced, the greater will be the flow, providing, of course, that an abundance of water is available.

"Back-blowing" can be applied to all wells operated by air lift. The top of the well casing should be sealed; next, by closing the discharge pipe while the air lift is in operation, the air will be forced through the foot piece and will drive the water ahead of it through the strainer and float the finer sand. Then, by opening the discharge, the flow will resume its course toward the surface and bring a portion of the floating sand with it. By a repetition of this operation and by increasing the back pressure if necessary, all of the fine sand immediately outside of the strainer will be collected outside of the screen in such quantities as to shut off the sand and increase the flow into a well, without changing the piping in the well. This process may be repeated at any time, so that the screen and adjacent strata can be kept clear.

Wells in Rock and in Fine Material.—When wells are drilled in rock, the action of the drilling tool forces the cuttings back into the crevices in the rock. These may be loosened and pumped out of the well in the same manner.

In the case of wells in fine material and quicksand it is often possible to set a strainer in the sand and drill auxiliary holes alongside the well down to the top of the strainer. Then foreign gravel may be dropped down, which will roll in alongside of the screen and take the place of the sand pumped out—often increasing the yield fourfold, by affording outside of the gravel bed a larger area through which the water may leave the sand.

North Carolina Section Am. W. W. Assoc. to Meet.—The North Carolina section of the American Waterworks Association will hold its annual meeting Nov. 14 and 15 at Gastonia, N. C. Prof. Thorndike Saville, Chapel Hill, N. C., is Secretary.

Present-Day Tars for Pipe Coatings

Paper Presented at Last Annual Convention of American Waterworks Association

By W. R. CONARD
Of Conard & Buzby, Consulting Engineers, Burlington, N. J.

More than 70 years ago a process for coating cast iron pipe using coal tar was developed by Doctor Angus Smith, and this process or variations of it have been in practically constant use since for cast iron, and it or coatings with an asphaltum base have been used for wrought iron and steel. For the smaller sizes of wrought pipe galvanizing has also been extensively used, as well as lead lined and cement lined. At the time, Doctor Smith got out his process "coal tar" was a residue of the manufacture of gas from coal, just as it is today, only in those days the many by-products to be obtained from this residue were apparently little known, and the tar was in every way and from every standpoint what is termed "virgin tar."

The Present Specifications.—The Standard Specifications of today says:

"Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300° immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipe is heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300° (or less if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed. Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated the pipe shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned."

All of this follows somewhat the specifications as first developed by Smith, but you will immediately note the term "Coal Tar Pitch Varnish." Pitch and varnish are used a number of times when, as a matter of fact, the material is not pitch nor is it varnish as they are generally understood. Pitch is the residue of tar after distilling, or is an extract of "pine tar," and varnish is generally understood as being a resinous product. Another thing the kind or kinds of oil and the proportions are not definitely stated, and in this connection variations in season and weather, and the opinions of individuals, should be offset by definite statement.

Average coal tar is made up of carbons, oils, acids and gases. The acids and gases in the forms of hydrogen, oxygen, nitrogen, sulphur. Its main body is carbon and it is the carbon held together by the oils which protects the metal from corrosion, and it is the acids that tend to attack and corrode. Therefore it is desirable to get for pipe coatings a tar as free from acids as may be, and as high in carbon and oils, especially the heavier oils, and to use the coating at temperatures that will not evaporate the oils.

Uses of Coal Tar and By-Products.—Coal tar and the by-products that are being extracted therefrom are put to a wide variety of uses. The heavier material usually called tar (no matter how much it has been distilled or refined) is used for paving, road work, the varying forms of roofing materials, such as paints, etc., while the lighter part is used in many lines of industry particularly the chemical, so that its value is greater for refining purposes than in its crude state, which condition is the best for pipe coating purposes. The result is that unless the pipe maker controls some source of production, he has to compete with the refiner, with the consequence that there are times when he gets left, and the pipe purchaser is the innocent sufferer. This does not mean that the pipe maker is willing that this be so, but it is simply a stress of circumstances.

It may prove to be several generations in the future before the supply of bituminous coal from which we get our tar is exhausted, but as the by-products become greater in variety and value the keener the pipe maker will have to compete, and the greater will become the cost. At present the tar used for pipe coatings is about 15 per cent of the total cost of coating pipe, and my thought is, when is the point going to be reached when economy ceases in using coal tar, and what other material or materials can take its place?

Virgin Tar Not Last Word in Pipe Coatings.—It is not the purpose of this paper to attempt to technically cover the ground that the subject of pipe coatings brings up, and it is the belief of the writer that "Present Day Tars for Pipe Coatings," while the pipe maker specifies and tries to get "Virgin Tar," that the tar does not contain as large a proportion of the heavy mineral oils as the tars of Doctor Angus Smith's time contained, so that there are cases where the coating is not as durable as it was once. It is my further belief that it is high time that careful and more extended studies, and research should be gone into to see what might be done about it, and I consider it entirely within the range of possibility that even using coal tars that have had their by-products extracted together with some other material or materials whether oils or some other form of binder that a better and more durable coating than at present can be found. I would not say to disregard tar entirely for as I view it there has not yet been found anything that could within economic limits take its place, but I do not think that the virgin tar of today is the last word in pipe coatings, and I do think thorough research would develop some other material to put with tar that would form a much better protection to iron and steel pipe surfaces than we are now using.

Investigations That Have Been Made.—When I speak of research work it does not mean that investigation has not been made for it has. Mr. Dexter Brackett, back in the eighteen nineties, made tests, keeping Mr. Thos. Wiggin at the foundries for many months to try and get better coating; Mr. Allen Hazen, in 1908-9, had some careful work done. Mr. Clarence Goldsmith, about 1913, for the Boston High Pressure Fire Service in collaboration with Mr. Frank McInnes, tried a variety of tar coatings. The result of Mr. Brackett's and Mr. Wiggin's work in large measure, gives the specification as at present written. Mr. Goldsmith's work gave a specification using tar and rosin, which gave a good appearing coating, but due to the temperatures used did not appear to have the lasting qualities required. The investigations of Mr. Hazen caused his conclusions to be for a tar distilled until the naptha was removed with enough linseed oil to give a smooth, tough and tenacious coating for steel pipe. As this apparently applies primarily to steel pipe, and I do not see it mentioned for cast iron it is rather assumed that the present standard requirements for cast iron are acquiesced in by Mr. Hazen.

Apparently all of these investigations looked up other materials, and by a greater or less eliminating process got back to coal tar. At the same time all apparently agree that the factors of: heat of the pipe for varying thicknesses, heat of the tar bath and keeping it of known proportions of fresh and old tar, knowing the temperatures of both pipe and bath and maintaining them at predetermined temperatures so as to obtain uniform results, are the prime factors, but all of this as indicated entails men of greater skill and intelligence than the average pipe coater; better, and more extensive apparatus and facilities for doing the work than exist as an average, even at the present time; and after these were attained a very strict adherence to them.

As Suggested Research.—From what I have observed of pipe which have been in service, and for some reason taken out my conclusion is that the coating on the pipe is not impervious to moisture, having small pores which usually extend through the coating. This allows the moisture to get to the metal, ferrous oxide forms coming out through these pores, and spreading over the interior of the pipe. Perhaps you may have noticed in pipe taken out that when you take off some of the scales formed that you will find apparently good coating underneath. Therefore, while as before stated, I do not see that tar should be disregarded, research should be made to see whether there is something to use with the tar that will seal the pores, which will prevent the forming of the ferrous oxide, and the formation of tubercles.

You get somewhat the same effect when pipe are allowed to lay out in the weather except that in that case the ferrous oxide begins to form under the coating and causes the coating to scale off. Also I believe that investigation should be made of whether pipe of different sizes and classes should be dipped in the tar bath at different temperatures, for the volume of the metal in the pipe controls the number of heat units to be thrown off before the coating can become set, and as long as the heat prevents the setting of the coating, the heat will also continue to evaporate the oils in the tar and tend to leave nothing but dead pitch.

As to what materials might be used in conjunction with tar to prevent the forming of iron oxide, there are these things that have occurred to me. One is the coating, especially of the interior of the pipe with some parrafin substance before applying the tar; this was suggested casually by Mr. S. B. Brown of Warren Foundry. The other is the use of some substance that has no oil or gas forming constituent, but is very dense and when set, impervious to moisture, which will become fluid at approximately the same temperature as tar, and will mix with tar readily, and can therefore be put in the tar tank, and applied in conjunction with the tar. And still another might be to find some means of getting a much thicker coating on the pipe, which would stay out, and not tend to scale in cold weather, and soften and run in hot weather. The City of Philadelphia did, and I think, still have a specification that the coating shall be at least 1/64 of an inch thick, which would help some, but I do not think is thick enough, and with the existing methods in vogue at the foundries, and the tars used is quite difficult of attainment.

If simply tars are to be used every known constituent should be determined, and careful experiments made in an endeavor to determine which are beneficial and which are harmful to pipe as a coating; just which will give the longest efficient life.

Summary.—Apparently present day virgin tars do not appear to contain as great an amount of the heavy oils as the old tars, and probably have more of the lighter oils which evaporate more readily.

Present day specifications are at variance with the process developed by Dr. Smith, and the demands of the pipe purchasers on the manufacturer have been such that the old Smith method, which was a rather lengthy operation and involved dipping the pipe cold in hot tar and allowing them to stay in the bath until the pipe became hot, could not be worked today unless much more elaborate apparatus than that of Doctor Smith's time were installed and this would be necessary to coat the present amount of pipe produced.

Research, if undertaken, should be along at least these two lines:

The apparatus necessary to care for the present day volume of production, going back to a strict adherence to the Doctor Angus Smith process, or,

Using present apparatus and methods, or something similar in rate of working, and find something to mix with the cheaper distilled tars to get a coating that will be as lasting and protective, or, if possible, more so than the old Smith process.

Removal of "Floating Islands" from Storage Reservoir

The flooded area of the storage reservoir of the waterworks of Charleston, S. C., had formerly been the site of numerous rice fields, which after abandonment of the rice-growing industry, had grown up in a heavy, rank, marsh grass. These grasses had sent their roots downward 2 or 3 ft. and in all directions, actually forming a very closely interwoven mattress of roots.

In constructing the reservoir no attempt was made to remove this vegetable growth and marsh mud, in fact, the cost would have been prohibitive. It was reasoned that the flooding of the marsh would kill all such vegetable matter and that within a reasonable short time nature would oxydize the organic matter. However, in the process of natural decay, the gasses formed were sufficient to cause this mattress of roots with its accompanying marsh mud to be torn away from the bottom soil and float to the surface, thereby defeating the object sought, the destruction of the marsh grasses.

Condition of Reservoir and Equipment for Removal of "Floating Islands."

In addition to the indigenous grasses, these floating islands offered a fertile soil for semi-aquatic and terrestrial plants and on the larger islands small willow cypress and pine trees began to grow. As these islands drifted back and forth in the reservoir with the wind and current, the water company had adopted a policy of anchoring them in the shallow portions of the basins, and in some instances had removed some of the islands that had floated into and blocked the spillway entrances. Further, the young willows had sent down roots to the bottom and quite large trees had grown. The rapid growth of the semi-aquatic plants, particularly that of alternanthera philoxeroides, threatened to cover the entire water surface and had begun to seriously interfere with the natural aeration of the water. The growth of the trees added a further menace in that they acted as a sail and might sometimes carry an island against the spillway, effectually blocking it up at a critical time. This, it is believed, was one of the contributory causes of the over-topping and failure of the earth embankment in July, 1916.

In 1917 the city purchased the waterworks, and in the fall of 1921 began the removal of some 50 acres of these islands.

No information could be obtained as to the best equipment adapted to do the work, so the Water Department had to adapt its existing equipment to the new problem.

The accompanying illustration reproduced from the 1921 report of the Commissioners of the Public Works, of which J. E. Gibson is manager and engineer, shows the equipment used.

The cost to Jan. 1, 1922, was as follows:

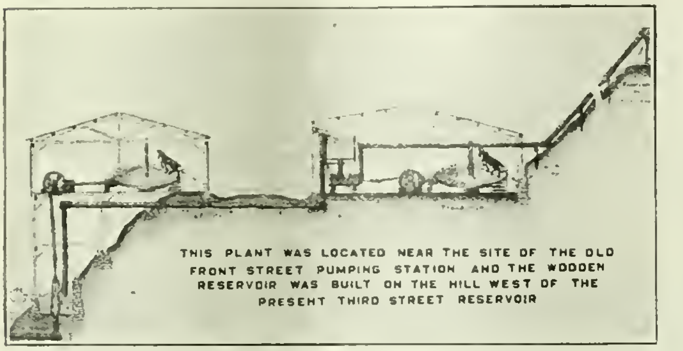
Equipment:	
2-8 ft. x 16 ft. lighters lashed together, complete	$1,017.85
Rake	244.77

Small boats, anchors, etc.	80.78	
Placing engine on lighters	56.15	
		$1,399.55
Operation:		
Repairs, equipment	$ 62.50	
Supplies other than fuel	206.31	
Fuel	208.22	
Engineering	50.00	
Superintendence and overhead	1,122.80	
Rental of hoisting engine and cable equipment	400.00	
Labor	3,314.98	
		5,374.84
Total cost to Jan. 1, 1922		$6,774.39

A Bit of Cincinnati Waterworks History

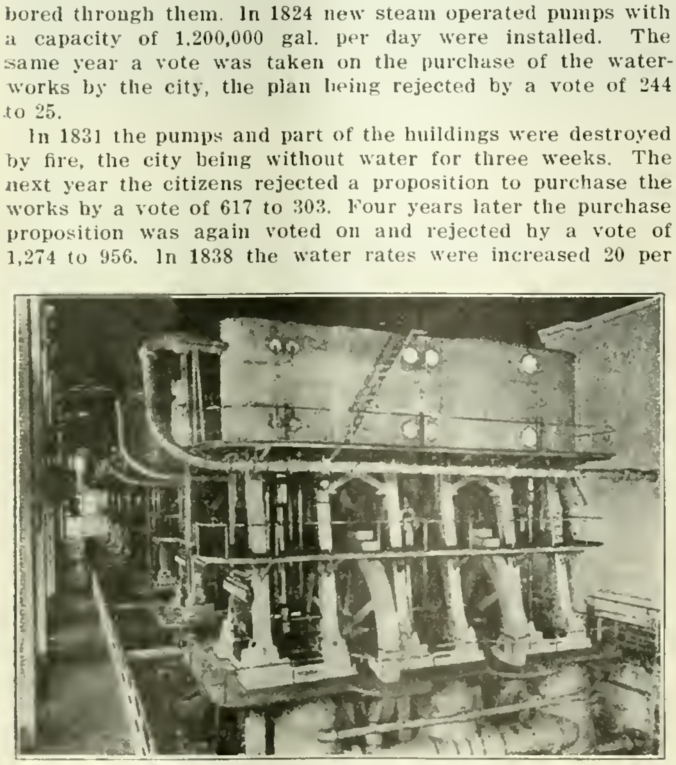
An interesting comparison of the pumping power of the waterworks at Cincinnati, O., in 1821 and 100 years later is furnished by the two illustrations below, reproduced for the recently issued report of the Cincinnati Waterworks Department for the years 1919-1921.

The first water was pumped on July 3, 1821. The works which were then privately owned consisted of two sets of pumps operated by horses or oxen on a circular treadmill, a tank on the north side of Front St. and a reservoir on the hillside. The pipes were made of logs with a 2½-in. hole bored through them. In 1824 new steam operated pumps with a capacity of 1,200,000 gal. per day were installed. The same year a vote was taken on the purchase of the waterworks by the city, the plan being rejected by a vote of 244 to 25.


THIS PLANT WAS LOCATED NEAR THE SITE OF THE OLD FRONT STREET PUMPING STATION AND THE WOODEN RESERVOIR WAS BUILT ON THE HILL WEST OF THE PRESENT THIRD STREET RESERVOIR

Original Pumping Power in 1821.

In 1831 the pumps and part of the buildings were destroyed by fire, the city being without water for three weeks. The next year the citizens rejected a proposition to purchase the works by a vote of 617 to 303. Four years later the purchase proposition was again voted on and rejected by a vote of 1,274 to 956. In 1838 the water rates were increased 20 per cent, and in October it was voted to purchase the works, the vote being 1,573 to 521.



Present Pumping Power in 1921.

In March, 1839, a new enabling act was passed by the legislature, and on May 3 another election was held, when purchase carried by a vote of 728 to 553. On June 25 the city took possession of the works, which consisted of a reservoir, 2 pumping engines, 3½ miles of iron pipe, and 19 miles of wooden pipe.

Effect of Soil Alkalis on Concrete Tile in Southwestern Minnesota

A report on the concrete alkali investigations carried out in Minnesota in 1919-20 by the Division of Agricultural Engineering of the United States Bureau of Public Roads in cooperation with the Minnesota Department of Drainage and Water has been issued recently. The summary and conclusions as given in the report follow.

Twenty distinct tile failures were examined in 17 different drainage systems in southwestern Minnesota and in all but three cases the total salt content of the drainwater exceeded 1,500 parts per million.

The real trouble is not, however, disintegration beginning on the interior surface of the wall of the tile through the action of the water carried by the drain, as this water represents the average condition for a large area; the trouble is caused by extreme conditions of the soil in direct contact with the outer surface of the tile wall. These conditions are fairly represented by the results of analyses of the soilwater and the extremes may be local in character or may represent considerable areas.

The danger limit of total salts in direct contact with the outer surface of concrete drain tile of the quality of the ordinary southwest Minnesota product, is about 3,000 parts per million when the salts consist almost wholly of the sulphates of magnesium, sodium, and calcium with the first two of these running near two-thirds or three-fourths of the total. The most pronounced failures have occurred where the total salt contest of the soilwater has exceeded 4,500 parts per million.

Tile have failed soonest after installation and the failures have been most pronounced at those points where the soilwater has been richest in total salts.

In view of the relation existing between the several failures of tile by disintegration and the percentage of sulphates in the soilwater, the conclusion has been reached that the sulphates are in a large measure directly responsible for the failures.

Characteristic failures are by disintegration beginning with a checking and cracking of the exterior surface of the tile wall followed by a very evident increase in volume of the mass; finally all binding principles of the cement disappear and the whole mass resembles a freshly-mixed batch of lime mortar concrete.

The exact chemical processes entering into the disintegration become considerably involved and much yet remains to be learned on this phase of the subject; but it can be said at this time that through interchange and replacement the final result in extreme cases is a loss of most of the cement.

There is at this time no known solution for the problem under consideration, but it has been found in the investigations that improperly-cured tile have quickly failed under conditions which better-cured replacement tile are resisting. There is every reason to believe, therefore, that a betterment in the quality of the tile in every possible detail will gratly minimize the difficulty in that the danger limit of the sulphate waters can thereby be considerably raised.

Until it is possible so to make concrete that it will definitely resist all action of sulphate waters, it is recommended that in doubtful areas soilwater samples be collected at intervals along the routes of proposed tile drains and submitted for analyses. If the results indicate sulphates in more than nominal quantities the use of concrete tile should not be considered.

Except where disintegration has resulted from the action of sulphates, concrete tile are giving satisfactory service throughout the area covered by the investigation. No indication of trouble was found, or is there anything to indicate by the results of the work to date that trouble is to be anticipated, in the four Iowa counties examined or in any of the following eight of the twenty-two Minnesota counties in which work was done: Blue Earth, Brown, Faribault, Martin, Nicollet, Pipestone, Rock and Watonwan. Conditions in the other fourteen counties are more or less spotted, with the center of the worst area running in a northwesterly course about as indicated on the accompanying map by the lines connecting the several tile failures.

Such physical tests as have been made indicate that the general quality of concrete tile manufactured in southwestern Minnesota tile plants during 1919 and 1920 was high enough to meet the requirements of the specifications for standard drain tile as compiled by the American Society for Testing Materials. Judging by such data as were obtained the tile manufactured previous to 1919 was somewhat inferior in quality to that now being made.

Refuse Destruction in Suction Gas Plant

From The Surveyor, London.

In a paper presented last June at the annual convention of the British Institute of Cleansing Superintendents, E. Hobson described some experiments he has made with a suction gas plant designed by Mr. John Wells, formerly inspector-general of mines for Egypt. The plant consisted of (a) a generator into which the material was fed, rectangular in plan, and built up of standard cast-iron plates; (b) a cascade scrubber in which the ascending gas met a stream of water flowing over a series of baffle plates, this action partially freeing the gas from some of its impurities; (c) a rotary tar extractor which completed the extraction of the tar; (d) a dry scrubber which completed the purification process and from which the gas passed on to the gas engine.

When used for boiler firing the scrubbers and tar extractor were cut out, and the gas was fed direct from the generator to the boiler through a Wells patent gas burner. The plant took up very little space—the one used at Leicester stood on a piece of ground about 12 ft. square. It was very simple, with no complicated parts to get out of order, and from what he had seen only required feeding to go on producing gas indefinitely.

The first material used was ordinary dry refuse, in lots averaging 46 cwt., collected from the bin districts in the city. The refuse was dumped down near the plant and forked over to get out the dust, tin cans, and all incombustible material. The selected portion consisted of paper, rags, vegetable matter, large cinders, pieces of wood, etc. This was then fed into the hopper, an ordinary ash-bin full at a time. It was found that the material from the Leicester refuse averaged about 47 per cent. Thus from 46 cwt. of refuse 21.6 cwt. of usable material was obtained which took 15 hours to put through the producer.

The gas obtained was used to drive a 50-hp. gas engine, operating an air compressor working at 100 lbs. per square inch, which at full load absorbed 20-hp. The residuals as taken from the producer were 10 per cent by bulk and 20 per cent by weight.

Another test was made by taking 16 cwt. of material such as would have been given off the tail-end of a screen. It consisted of paper, rags, cardboard boxes, vegetable matter, etc. This was fed into the hopper as in the other cases, but it was necessary to feed slightly quicker—owing, Mr. Hobson imagined, to the lighter nature of the fuel—and took ten hours to put through. The gas engine and air compressor were kept running continuously, and although there was not the reserve of power that was obtained from the heavier material there was sufficient to keep up the air pressure to 100 lbs., and therefore it was quit safe to say that 200-hp. hours were developed. He had also tested ordinary market refuse taken direct from the markets, and a similar result was obtained. There was very little residue in either case.

There might be considerable doubt at present as to whether it would be wise to put down a gas plant to deal with the whole of a town's refuse; yet he was certain that if the matter was thoroughly gone into, and systematic tests made with proper appliances, results would be obtained that would be very interesting if not surprising, and whether it was found suitable or not for dealing with the refuse in bulk. Mr. Hobson was confident that it would prove a valuable adjunct as an auxiliary to a screening plant to take the tailings from the screen, which at present were, in many cases, wasted; or even to a destructor where a considerable amount of light refuse and market refuse had to be dealt with, and with proper use made of the power produced it would help to get rid in a profitable manner of a class of refuse which was often difficult to deal with, and would be another source of power. If used in connection with a screening plant, the power obtained from the tailings consisting of paper, cardboard, vegetable matter, etc., should be sufficient to run and light the plant. The cinders could then be used for other purposes, such as boiler firing, where it was not necessary to use a high grade fuel, or they could be made into briquettes, and so produce a fuel at least as good as some of the coal being obtained at the present time.

Another feature in connection with gas production that should receive attention, was that if material was available (and it should not be difficult to arrange that there was always a day's supply in hand) and the feeding was properly attended to, the supply of gas was fairly constant.

New Plant to Make 1¼ Inch to 6 Inch Cast Iron Pipe with Precalked Joint

The McWane Cast Iron Pipe Co., of Birmingham, Ala., is preparing to let contracts for construction of the first unit of its new plant. It is to be one of the most modern in the country and will specialize for the immediate future on manufacturing the smaller sizes of cast iron pipe, from 1¼ to 6 ins., equipped with the McWane precalked joint.

While the company itself is comparatively new in the field, having been organized early this year, its president, J. R. McWane, has long been a national figure in the cast iron pipe industry. He headed the American Cast Iron Pipe Co. of Birmingham from 1907 until 1921, only leaving there to organize and direct his present company. James D. Sample, formerly assistant to the president of the American company, is associated with Mr. McWane as vice-president.

The McWane precalked joint is an invention of Mr. McWane's that is the outcome of 8 years of research toward a better joint for cast iron pipe. In contrast to the old laborious methods of handcalking joints in the trench, with the attendant disadvantages of "bell holes," yarning, and handling molten lead, the new joint is factory-made, up to the final blows of the calking tool. Briefly, the process is to stand the pipe to be precalked vertically in racks, bell end upward. A mandrel, very slightly larger than the spigot end of the pipe it represents, is inserted in the bell. Around it braided hemp packing, a specially-prepared ring of close-set iron wedges, and two more braids of hemp are placed, with a final filling of lead. Then pneumatic calking tools are brought into play to calk the joint thoroughly for one-half of its circumference. In laying this pipe nothing is necessary in the field except to extract the protecting wooden blocks, insert the plain end of one pipe into the bell of another, calk the remaining half of the outer lead ring (which is placed uppermost), touch up the bottom with a special offset tool, and the joint is complete.

The 1¼-in. size opens up the field of service connections for cast iron pipe.

The new plant will have a capacity of 8,000 ft. of pipe per day, will employ 150 men, and is expected to be in operation by March 1, 1923.

Interposed Layer of Fine Sand in Filtering Media

From The Surveyor, London.

In a paper presented at the annual summer meeting of the British Institution of Water Engineers, F. Storr and C. W. Bennett, described the slow sand filter of Chester, England. The arrangement of the filtering media is as follows:

	Ft.	Ins.
Perforated bricks on filter bottom	0	4½
Pebbles passing ¾-in. mesh	0	4
Fine pebbles passing ¼-in. mesh	0	2
Coarse pit sand 60 per cent retained on 40 per inch mesh	1	3
Fine pit sand 65 per cent retained on 70 per inch mesh	1	0
Coarse pit sand 60 per cent retained on 40 per inch mesh	1	3
Total depth	4	4½

This form of filter has been in use for many years and yields exceptionally good results. "The interposition of the layer of fine sand," the paper states, "has been the subject of much criticism, but it has stood the test of time, and there is no doubt the remarkable results obtained are in a great measure due to its action.

"As is well known, it is a comparatively simple matter to reduce by filtration the total bacteria contained in a raw water from thousands per cubic centimetre to hundreds, or perhaps tens, but reduction below some such limit can seldom be continuously relied upon by the ordinary practice, and it is in effecting this object that the interposed layer of finer sand serves so useful and important a function. It is true that sub-surface clogging takes place to a slight extent in course of time, but this is remedied by going down to the fine sand-layer and removing a light scraping from its upper surface when replenishing the coarse sand removed by successive cleanings.

"There are practical reasons why the fine sand should not be placed on the top, as the trampling it would receive in the course of cleanings would quickly reduce it to an impervious mass, and when removed to the sand-washers, together with algae, mud, and other debris, it would not be so readily dealt with as with the coarser grade of sand."

"The rate of filtration varies from ¾ gal. to 2 gal. per square foot per hour."

City Managers for Small Towns

Advantages of the commissioner-manager plan upon places having populations of 500 to 5,000 were pointed out by Mr. A. W. Seng, city manager of Hays, Kan., in an article in the June Kansas Municipalities, from which we quote as follows:

Advantages of 3-Man Commission.—A commission of three men where the commissioners are elected at large, is better than a council of five, seven or nine men, where the councilmen are elected by wards. This at once does away with political obligations and ward jealousies between residents of the different wards. The city's money may be spent for public improvements where it will do the most good and does not have to be divided up amongst the different wards in order to appease a belligerent constituency.

A further advantage in having a 3-man commission is that of administrative organization in the form of department committees. Instead of having about three men on each committee, none of which usually have any time to attend to the business in hand, hoping that the other will attend to it, the commission form has one-man committees. Since there is but one of him he cannot put off on the other fellow but must do it himself and he does it, usually with the encouragement and assistance of the manager.

If the manager wishes to confer with a certain committee all he has to do is to call at the office or place of business of the committeeman of the department which he wishes to discuss and the subject is outlined, discussed, or completed and closed as the case may be and none of the other commissioners need be bothered and a lot of valuable time is saved thereby and the object accomplished.

Technical Engineer as Manager.—In order to save the hiring of extra trained men it is very desirable that the city manager should be a graduate or professional engineer. In this way the offices of city engineer, superintendent of light, water and sewer departments and commissioner of streets may be combined and taken care of by the manager. It is of course understood that he has direct supervision of the city's accounts, keeps in constant touch with the citizens of the town and takes care of all complaints in a satisfactory manner.

It is a great advantage for a small city to have an engineer for city manager because, if it is a growing city, he can establish grades for streets and sidewalks, do the city surveying, make sewer extensions, water main extensions, build small bridges, work out power plant development and possibly do the engineering work for street paving. He also can give expert advice to industrial concerns of the city in a small way where it would not warrant the hiring of a consulting engineering firm. All this work is in the way of saving money for the city if the manager is a man who can handle development work as he should be able to do. If it is necessary to let large contracts for public works the manager is always on the job to see that specifications are strictly followed or allow such changes to be made as he may deem necessary for the best interests of the city. Very frequently, on small jobs, he can have the work done by organizing a crew and purchasing the material on the wholesale market, thereby eliminating the contractor's profit.

Preparing the Annual Budget.—One great advantage of the commission-manager form is the annual budget for making the tax levy, the manager is in a better position to know and figure out the needs and financial condition of the city than any other man. After allowing for the fixed overhead expense of the city in the way of sinking fund, interest on bonds, taxes, insurance, salaries, and so forth, he can make a very close estimate on the needs of the city in regard to needed improvements, extensions, and general expenses. This is all made into the budget and must be submitted to the taxpayers of the city for discussion and explanation. It is then published in the local paper and submitted to the commissioners for approval and adoption, after which it must again be submitted to the taxpayers before it can become a levy for the city taxes and sent to the county clerk. The law which established the city manager form in Kansas does not allow the city to spend any more money from any one fund than is provided for in the budget, hence there can be no chance for having a floating indebtedness which would have to be funded later. It can readily be seen that this is a great advantage to any city because the taxpayer has the opportunity to know just how much it is going to cost to run the city and that no more can be spent. The budget must cover all expenses.

Monthly Report of Manager.—In this same law it is provided that the manager prepare a monthly report to the board of commissioners for approval, showing:

- Finances.
  - Money received from all departments.
  - Money spent in all departments.
- Public Health Department.
  - Contagious and infectious diseases.
  - Condition of quarantine.
  - Abatement of nuisances.

Public Safety.

- Public Utilities.
  - Cost of production and distribution.
  - Income.
  - Extensions and improvements.
- Street & Alley Department.
  - Improvement and cost of same.
- Anything else of interest.
- Recommendations for new improvements.
- New ordinances.

This report is open for the inspection of the public and may be printed in the local papers.

All this obviously tends toward greater efficiency and economy in administration and better service to the public in all departments. It is much easier to select three good men for commissioners by the entire voting population than it is to select a larger number by wards. In this way each voter gets to vote for all the candidates instead of only one or two. The board of commissioners then hires a manager and holds him responsible for the proper administration of the city's affairs. Since the manager's powers are only administrative and not legislative, and since he is always under the direct supervision of and entirely responsible to the commissioners there is not the remotest chance for him to become anything except what he is hired for and that is a public servant. He is hired for his qualifications and ability and because his education and experience make him peculiarly fitted for the job. At present there are very few men who have had the experience and other qualifications necessary to make them competent managers right from the start and the demand has been greater than the supply. The next five years will undoubtedly see an enormous change in favor of the commission-manager form and consequently there will be a great demand for the right kind of men for managers.

Personals

Albert H. Mainwaring has been appointed supervising engineer of the Bureau of Highways of the city of Philadelphia.

Carlos W. del Plaine, C. E., has joined the staff of the League of Minnesota Municipalities as field agent. The league's executive office is at Minneapolis.

Nicholas S. Hill, Jr., and S. F. Ferguson, consulting engineers, 112 East 19th St., New York City, have dissolved partnership and the business henceforth will be conducted by Mr. Hill alone.

Raymond J. Richardson, of Reading, Pa., has been appointed, assistant professor in the Department of Architecture at Carnegie Institute of Technology, Pittsburgh. His duties begin with the fall semester of 1922.

Calvin W. Rice, secretary of the American Society of Mechanical Engineers, has been named by the principal engineering societies of the United States to represent the American engineering profession at the International Engineering Congress at Rio de Janeiro.

M. P. Tucker, for the past three months service director for the city of Akron, Ohio, has been appointed chief administrator of the city, the appointment taking effect Sept. 1. Mr. Tucker succeeds Homer C. Campbell, who has resigned to take an administrative position with the Firestone Tire Co.

M. W. Cowles has resigned as assistant sanitary engineer with the Illinois State Department of Public Health, to become associated with Clarence W. Marsh, 101 Park Ave., New York City in developing Marsh electro-chlorine batteries for the electrolytic production of chlorine at the point of consumption for use i waterworks, swimming pools, and for other sanitary and industria requirements. Mr. Cowles entered the service of the state o Illinois in 1916 and since that time has been directly connecte with water supply activities and for the past two years has bee serving as senior assistant engineer in charge of public water supplies, including certification of all railroad water supplies in cooperation with the U. S. Public Health Service.

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Roads and Streets—1st Wednesday
- (a) Roads
- (b) Quarries and Pits
- (c) Streets
- (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
- (a) Water Works
- (b) Irrigation and Drainage
- (c) Sewers and Sanitation
- (d) Waterways

Railways—3rd Wednesday
- (a) Steam Railway Construction and Maintenance
- (b) Electric Railway Construction and Maintenance
- (c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures

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Counting the Railway's Ribs

Although public utility commissions have usually recognized the necessity of raising rates sufficiently to cover increases in operating expenses, they have not usually seen the necessity of providing stockholders with larger dividends to cover the decreased purchasing power of the dollar. There seems, however, to be a growing recognition of the equity in granting increased "wages" to capital as well as to labor. Thus, in its recent order authorizing the United Railways of St. Louis to collect a maximum fare of 7 cts., the Public Service Commission pointed out that since the dollar of 1922 has but 65 per cent of the buying power of the dollar of 1914, a fare of 7.7 cts. in 1922 would be the equivalent of a 5-ct. fare in 1914.

It is true that the U. S. Supreme Court has long held that the present value and not the investment cost is the base for ratemaking, but most public utility commissions have virtually ignored this Supreme Court ruling, and have adhered to original cost as the rate base. We do not doubt that gradually the ratemaking commissions will adopt the Supreme Court point of view, not only because it is the law but because it is a just point of view.

The common argument against present value as a base for ratemaking is that it gives the investor an "unearned increment." There is, it is true, an increment in dollars, but not in the buying power of those dollars; and, after all, everyone is concerned ultimately not in the number of dollars that he owns but in the quantity of goods and services that they will buy. An 8 per cent dividend on $165 today will buy no more goods or services at retail than an 8 per cent dividend on $100 would buy in 1913 or 1914. Hence if railway or other public service property is valued today at 65 per cent above its 1914 cost, and if the same percentage of annual returns is earned today as in 1914, the owner of the property is securing no greater annual income, measured in goods and services, than he secured in 1914.

As a matter of fact, however, very few railways or other public service properties are being allowed to earn a fair return on the present cost of reproducing their plants. On the other hand, most owners of industrial plants have been earning a reasonable return on the cost of reproducing their property. Illustrative of this is the fact that the stock of 25 leading industrial companies is quoted at 65 per cent above their average pre-war price, whereas the stock of 25 leading railway companies is quoted at 25 per cent below their average pre-war price. Put differently, if the stockholders in those 25 railways had sold out in 1913 and had bought the stock of typical industrial properties, they would be more than twice as well off as they are.

Knowledge of just such facts as this accounts for the poor financial standing of railway stock today. The railways have been economically starved by the public acting through the Interstate Commerce Commission. At last the sight of the ribs showing through the hide of the railway body has begun to arrest public attention sufficiently to arouse hope that the next decade will witness a more favorable public treatment of the railways than they have received during the past 15 years.

Under-Valuations Made by the I. C. C.

Judging from the last annual reports to stockholders, tentative valuations of a large number of railway systems will be made by the Interstate Commerce Commission before the end of 1922. The valuations thus far made by the I. C. C. are based on 1915 prices. It is a conservative estimate to put present railway construction and equipment costs fully 50 per cent above those of 1915, and the probability is that such costs will average higher during the next two years than at present. Hence when the Supreme Court begins to review the valuations made by the I. C. C. it is probable that the Court will conclude that they should be raised fully 50 per cent.

It is noteworthy also that the I. C. C. deducts depreciation from the reproduction costs of 1915, but adds nothing for "development cost," "going value," or the like. Here again the Supreme Court will probably compel a revision of the I. C. C. valuations.

Once an inventory of all the property of a railway has been taken, it is a comparatively quick and inexpensive process to price it out, so that revised appraisals at present prices can be speedily made.

We hope to see some large railway company take issue at an early day with the valuation assigned to it by the I. C. C. and carry the case to the Supreme Court. Then, and not till then, will the investing public fully realize that railway investments are to be much safer in the future than they have been in the past.

A Queer Definition of Economics

In his "Principles of the New Economics," Prof. Lionel D. Edie gives this definition: "Economics is the science of human nature in its relations to the ordinary business of life."

By way of contrast we give a definition that appeared in these columns not long ago: Economics is the science of securing a maximum net income under given conditions.

Certainly the latter definition is broader than the former and more in accord with the prevalent conception of economics. Moreover, it should be obvious that there is far more to the science of economics than psychological factors. For example, before an economic railway location can be made a study of the topography of the possible routes must be made. Wherein is such a physical study included in Prof. Edie's definition of economics?

Railway engineers who have read Wellington's "Economic Theory of Railway Location" will have little difficulty in pointing out the defects of Prof. Edie's definition. Should refuge be taken in the explanation that Prof. Edie had in mind only one branch of economics, the reply is that neither his definition nor the book in which it appears can be used to justify such an explanation.

Prof. Edie says: "Economics is not mainly the science of things; it is the science of life." Here he apparently concedes that economics at least partly involves the science of physical things, while claiming that it involves mainly the science of psychology. He would find it difficult to sustain even this modified conception; for how can the relative economic importance of mental and physical forces be determined?

The plain truth is that Prof. Edie, like so many authors of would-be scientific treatises, has made no careful study of that branch of logic that relates to definition. And we suspect that he is not very familiar with formal logic in any of its branches.

How to Eliminate Misfiring of Center Shots

In large-scale blasting, it is customary to fire many shots simultaneously. The electric detonators are usually connected in series, and are fired either from a power circuit or from a blasting machine with large capacity, operated by hand. When firing with a blasting machine, trouble with missed shots has been frequently experienced. Under these circumstances, the shots that fail to fire are often a group in the center of the series. Tests to determine the causes of these failures have been made by the electrical section of the U. S. Bureau of Mines. In the August report of Investigations of the Bureau the following conclusions and recommendations are given. Various explanations have been given as to the cause of the failures. This paper covers a few tests made by the electrical section of the Bureau of Mines, which may be helpful in understanding the probable cause of the misfiring of center shots.

The results of these tests showed that if a large number of the common electric detonators are connected in series and fired under wet earth conditions, a large leakage of firing current occurs, and the detonators at each end of the series circuit may fire while the middle ones misfire. The detonators near the positive end will fire because not enough leakage has occurred to cause a misfire; those near the negative end will fire because enough current has returned to the circuit.

The reason why the middle detonators misfire is not necessarily because the current through them is too small to fire an electric detonator, but because it is not sufficient to fire them before the firing of the end detonators has opened the circuit. It has been found in practice, using hand-operated machines, that such misfires are more dependent on the current gradient in the circuit than upon the minimum value of current, and that it does not help much to increase the firing current to the amount given by a larger hand-operated machine.

As a means toward the elimination of the misfiring of center shots, it is recommended that the following practices be used whenever shots are to be fired in wet holes:

1. Use waterproofed electric detonators with enameled leg wires. When making connections with enameled leg wires, care must be taken to scrape the ends of the wires well, otherwise the enamel will prevent good electrical contact.
2. Fire the shots from an underground power circuit that has a capacity of at least 30 K.W.
3. Use extra care when tamping the holes in order not to damage the insulation of the leg wires.
4. Arrange the connections between the detonators so that they are supported clear of the earth or any other conducting medium.

Gasoline Rail Cars for Short Line Railroads

Results of an investigation of gasoline propelled railway motor cars, conducted for the member line of the American Short Line Railroad Association, were summarized by J. W. Cain, Purchasing Agent of the Association in a discussion at a recent meeting of the Metropolitan section of the Society of Automotive Engineers. Extracts from Mr. Cain's discussions follow:

As a result of investigation by the American Short Line Railway Association, it was found that the most successful cars in service were those of light design, using a thoroughly tried and proved make of motor-truck power-unit or chassis. One make in particular showed a preponderance over all others in the ratio of probably 5 to 1. Records were furnished of cars that had made as high as 300,000 miles, and which had been in practically continuous service for a period of five years. The operating cost varied from 10 to 25 ct. per mile and gasoline consumption from 5 to 10 miles per gallon. It was found that the maintenance cost was surprisingly low, averaging about $15 per month on these smaller type cars and only slightly above this on the larger ones. By smaller type is meant those using a 2½ or 3-ton motor-truck chassis, and by large cars those using 5-ton chassis. The operating cost of 10 ct. per mile was, of course, confined to the former, which were being operated by one man. But some of the larger types using two men were being operated as low as 20 ct. per car mile, as given in the following table; the figures in this table were made on a basis of $12,500, the purchase price of the car, and an operation of 100 miles per day:

	Cost per mile.
Gasoline	$0.030
Labor, 2 men at $125 per month	0.085
Depreciation, rate 12½ per cent	0.042
Interest and insurance	0.022
Maintenance	0.021
Total	$0.200

It was revealed that the majority of cars on the short lines were being operated most successfully by younger men, who were trained as mechanics and who were thus able to take care of practically all of the necessary light repairs. This is a point that should be emphasized strongly, as the labor cost is one of the principal single items in the operation of motor rail cars and the payment of standard wages would defeat the object to be accomplished, at least this is true on the short lines. The short line railroads have taken the position that the operation of these cars does not require the skill or training necessary to operate a steam locomotive. They have never been classified by the Interstate Commerce Commission.

The consensus of opinion by the short lines was that all cars should be equipped with a pivotal lead truck for safety and that a single pair of drivers with the proper weight distribution gave satisfactory service, though the riding qualities of the car were naturally not as good as though a 4-wheel truck with swing bolster were employed.

Enlargement of Railroad Yards and Engine Facilities at Moncton

Construction Methods Employed to Minimize Interference with Traffic Described in Paper Presented Sept. 7 Before Engineering Institute of Canada

By S. B. WASS,

Terminal Engineer, Canadian National Rys., Fort William, Ont.

The City of Moncton is situated on the Canadian Government Railways at the junction of the main line from Halifax to Montreal and the line from the city of St. John, and is also the eastern terminus of the Transcontinental Railway, which makes it the gathering point for traffic from the west to Halifax, Sydney and all points east of it, as well as the breaking up point for traffic in the opposite direction. By reason of this fact it is the most important railway junction point in the Maritime Provinces, and requires adequate facilities for handling traffic rapidly and efficiently, and also for distributing empty cars and equipment of all descriptions to points where needed. For a number of years the yard has been too small to provide the necessary working capacity; and the tracks too short to accommodate the long trains hauled by the new large locomotives. The roundhouse and other facilities, which were old, were too small and without proper facilities for making the running repairs to the present-day large locomotives.

Layout of the Yard and Its Approaches.—The old connection with the main line and trans-continental line, with the yard, is near the east end, and is by means of a wye connection. The tracks parallel to the west leg of the wye were used for a freight receiving yard, and those parallel to the east leg as a departure yard. These tracks were too short to hold the long trains, which resulted in a great deal of terminal detention. To eliminate this condition, and so simplify yard movements, a diversion was constructed from Mile 3.5 on the north main line to Mile 2.5 on the St. John subdivision, thence parallel to the St. John subdivision to the yard. By this means all traffic enters the yard from the west, making a simple east and west yard, except for the transfer to the Moncton shops, which traffic, being only local, is small.

A very complete ultimate layout has been designed, which includes east and west receiving yards, classification yards, which may be equipped with humps if required; east and west departure yards, transfer and storage tracks, new car repair facilities, new engine facilities, etc., so located that the construction of any additions or extensions required to meet traffic conditions may be carried on without materially interfering with traffic. This yard is arranged in units, so that it may be constructed and operated in sections as the traffic demands. The conception and design of this general layout originated with Collingwood B. Brown, recently chief engineer, Canadian Government Railways, and now engineering assistant to the vice-president, Canadian National Railways, Toronto. All of the expenditures and construction up to date have been in accordance with this ultimate layout.

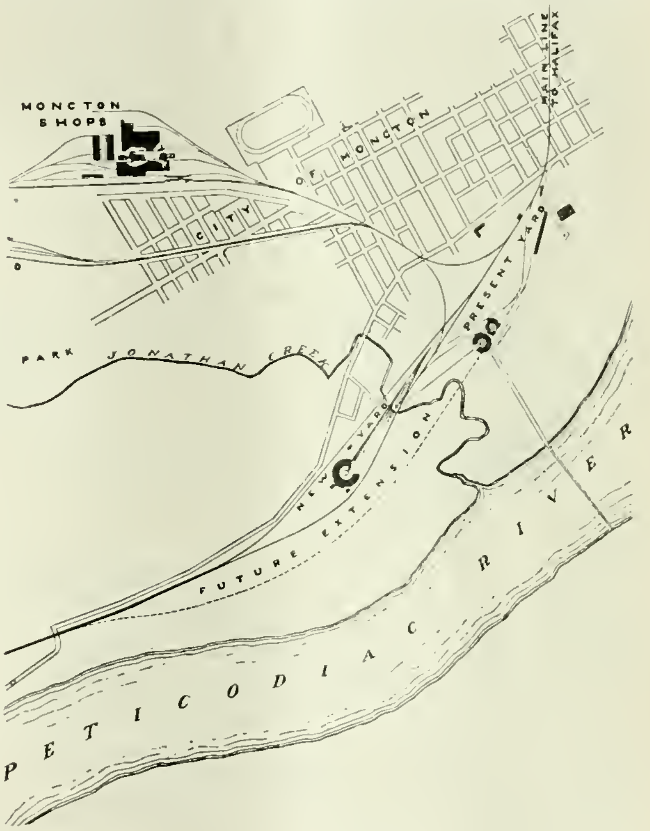
General Features of Construction.—The actual work of construction was commenced in the season of 1919, and consisted of three parts:

(1) The acquiring of additional land which was required on both sides of the present yard to provide for present and future requirements, and to avoid farm crossings.

(2) The construction of the diversion from the main line to the north, referred to above. The maximum grade used was 0.6 per cent, compensated for curvature, and involved the raising of the St. John subdivision to a height of 6.5 feet at the under crossing of the Salisbury road, Mile 1.8, and extension of this bridge from a single-track to a three-track structure. The contract for this work was awarded to the Dominion Construction Co., Ltd., and Wheaton, late in the season of 1919, and the work was completed early in 1920. A considerable saving in operating expenses was effected during the first winter by the use of this diversion for freight movement, although the old line was continued for passenger traffic use.

(3) The old freight shed was very inadequate for the local and transfer traffic. A new shed with additional trackage, arranged to conform with the new layout, was constructed. The structure is 400 ft. long by 40 ft. wide, of brick and structural steel construction. The contract for this work was awarded to engineers and contractors of St. John, and the work was completed early in the season of 1920. A transfer platform 500 ft. long was also constructed, conforming to the new layout.

Construction Work During 1920.—The engine house, coaling plant and other engine facilities are located on the high ground, where the foundation is good, just west of Johnathan creek, which crosses the yard at about Mile 0.6 and flows across the marsh, the level of which is approximately 25 ft. below the grade elevation. This marsh has an average width of about 400 ft., the Johnathan creek culvert being located at its extreme west side. The ground west of the culvert for a distance of 5,000 ft. was generally above grade ranging from zero to 15 ft., which necessitated considerable excavation. The material was required partly to widen the embankment at the extreme west end of the yard, but mostly to make the embankment over the Johnathan creek marsh.

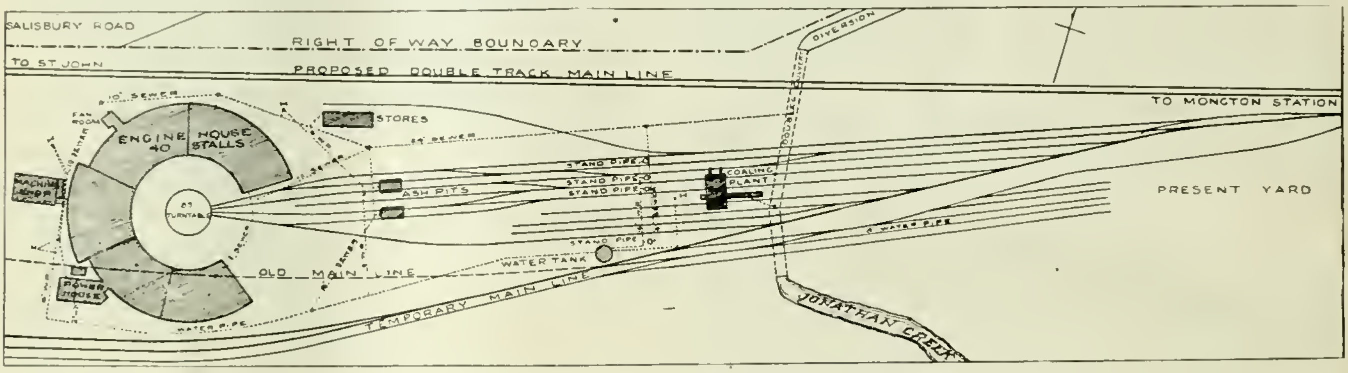


Plan of Yard Layout with Approaches.

An extension of the Johnathan creek culvert under the old yard was also necessary. This culvert is a double 6 ft. x 6 ft. concrete rail top structure and the extension on its upper end is 312 ft. long. The original stream crossing the marsh diagonally necessitated a division to bring it to the inlet of culvert. In order to have the site ready for building during the season of 1921, the construction of the culvert extension and grading for the site of the building was performed in 1920, so far as it could be done. A contract for this work was awarded to the Dominion Construction Co., Ltd., and Wheaton, and the work was completed by the end of 1920, about 95,000 cu. yd. of material having been excavated, and the culvert extension and stream diversion completed.

Method of Handling Excavation.—One special feature of this work is worthy of mention, namely, the efficient method of handling the foundation excavation from the culvert and the excavation for the stream diversion. For this work a movable stiff-leg derrick on a base of heavy hard pine timber was constructed, and on it was mounted the hoisting engine, which served at once as a counter weight and supplied the power for operating the derrick for handling heavy material, the orange-peel bucket for excavating, and was also used to propel the whole apparatus by means of deadmen. This machine was placed ahead of the work and rested on a grillage of timber and rails which distributed the load over considerable area so that no difficulty was encountered supporting the machine, as is so frequently the case in handling movable derrick apparatus close to the edge of excavation.

Work During 1921.—The work during 1921 consisted of continuing the grading, diverting the main line, and construction of buildings and service tracks as shown in figure No. 2. It will be seen that a locomotive approaching the facilities will, under ordinary conditions, obtain the necessary attention in the following order: coaling and sand, water, fire cleaning, housing. Three inbound and three outbound tracks have been provided, all of which are served by stand-pipes for water. Coaling facilities are provided on the three inbound tracks, and by means of cross-overs, locomotives on two of the outbound tracks may be coaled with very little interference with the inbound locomotives. Four tracks have been provided with ash-pits and sufficient cross-overs have been provided to facilitate any desired movement of the locomotives. Fifty tracks to the turntable have been provided for, four are running tracks to and from the turntable, forty are entrances from the turntable to the forty-stall house, which is now constructed, and space for an additional six-stall section when required. All buildings except the water tank and coaling plant are constructed of brick on concrete foundations with mill type frames of B.C. fir, except the machine shop which has a structural steel frame. This is one of the largest layouts for a single engine house in Canada.



Plan Showing Layout of Engine Facilities, Moncton, N. B.

As much of this work had to be performed in the present yard, without interference with traffic, it was decided to do it by the railway's own forces under the supervision of the chief engineer, A. F. Stewart, with the construction engineer, S. B. Wass, and assistant engineers, E. R. Evans and H. L. Currie, directly in charge of the work.

When the work was approved very few detail drawings were prepared, and these were made as quickly as possible in the chief engineer's office by H. J. Crudge, assistant engineer of buildings, R. G. Gage, signal and electrical engineer, and C. S. G. Rogers, assistant engineer of bridges, for ash-pits, and steel water tank. The field work was divided into two units, each reporting to the construction engineer, and each consisting of assistant engineer and a small staff, with general foreman, and as many other foremen as necessary. One timekeeper and one materialman, with some temporary assistants were employed on the whole work. E. R. Evans was assistant engineer in charge of grading, etc., with T. McPherson as general foreman, and H. L. Currie was assistant engineer in charge of buildings, with D. A. Seaman as general foreman. G. N. Allen was timekeeper on the whole work. Special attention was given to the design and installation of the heating and piping systems by H. F. Finnemore, and to lighting by F. H. Williams, both assistants to Mr. Gage.

Several small contracts were awarded for special work as follows: Steel water tank, Dominion Bridge Co., Montreal; coaling plant machinery, Williams & Wilson, Montreal; tar and gravel roof, Carrite Co., St. John; plumbing, Johnston Bros., Moncton; oil storage system, B. F. Bowser Co., Toronto.

Grading.—The main line of the St. John subdivision and the Reid's cut yard lay across the site of the proposed engine house, on a grade, and at a different elevation than that of the new work. It was therefore necessary to construct a new main line well in advance of building operations. Owing to the necessity of maintaining traffic, cutting both sides and under the main line, and to the irregular shape of the excavation required, ten cuts of the shovel were required; this with the shallow excavation, varying from 2 to 15 ft., entailed a comparatively large amount of shifting of the shovel. The material encountered was heavy clay and hard pan. Some of it was used to widen the embankments at the west end of the yard, but most of it was deposited in the embankment over Johnathan creek marsh. The equipment used consisted of one model 60 Marion steam shovel, 24 Kilbourne & Jacobs 16-yd. air dump cars, one Jordon spreader, and two Consolidated locomotives.

In view of the shallow excavation and the settlement in the marsh, the shovel record would seem to be good. The shovel started work on April 11 and completed Sept. 14, having excavated 158,000 cu. yds., averaging 31,600 cu. yds. per month, or 1,200 cu. yds. per working day.

Sewer System.—As the buildings were all located on the natural ground, composed of hard pan, very impervious to water, it was important that drainage be provided for the foundation excavations at the earliest possible moment, and the most effective method was to get the permanent sewerage system installed. This was entirely new and independent of all other sewers except for the coaling plant sewer, which, on account of its proximity to the culvert, has a separate connection with it. It discharges into the top of Johnathan creek culvert through a specially constructed manhole near its upper end.

The main sewer, extending from the outlet to the manhole opposite the ash pits, is of 24-in. double strength vitrified clay pipe, 798 ft. long, placed 14 ft. below grade so as to drain the ash pits. From this main sewer branches of smaller sized pipe are carried to the turntable pit, engine wheel drop pits, and all other facilities requiring drainage.

Trench Excavation with Railroad Ditcher.—The total amount of excavation for sewer trenches was 4,960 cu. yds. in hard pan material merging into rock, so that hand labor was considered to be too slow. Several alternative methods were discussed and it was finally decided to try a Marion railroad ditcher which was available. This machine was supported over the top of the trench on old bridge stringers and in one operation excavated the trench in front of it and deposited the material behind itself, the pipe having been laid and jointed by men working directly underneath the machine. Some difficulty was encountered with a seam of quicksand about 10 ft. below the surface which caused the sides of the trench to cave in, but this was only for a short distance. The machine would dig only about 10 ft. below its support, so in order to excavate the bottom of the trench the machine had to make a surface cut, about 4 ft. deep, wide enough to permit the timbers to rest on the bottom of it. So successful was this method that frequently 55 lin. ft. of completed sewer was laid in a working day, and an average of 32 lin. ft. per day was maintained during the whole sewer operation. The cost of trenching under the conditions encountered was easily less than half what it would have been by hand. The main sewer was commenced on April 28 and was carried almost to the turntable, so that all foundations could be readily drained by May 30. The early completion of this sewer removed all necessity of pumping water from foundations.

Description of Buildings.—The stall engine house contains 40 stalls, 33 of which are 100 ft. in length with 65-ft. pits, and seven are 120 ft. long with 80-ft. pits. The house is divided into sections each of which is separated from the adjoining sections by fire-proof walls and doors. The sections are as follows: Commencing on the southeasterly corner, two sections of seven 100-ft. stalls; one section of seven 120-ft. stalls; one section of nine 100-ft. stalls, and one section of ten 100-ft. stalls. Three of the long stalls are provided with drop pits for driving wheels, and two with drop pits for tender wheels, so located that any pair of wheels on any of the railway's existing locomotives may be changed. The drop pits are all equipped with Taylor-Arnold pneumatic jacks. Each stall is provided with steam blower, with Barco connection, blow-off pipe, wash-out and boiler filling pipe, cold water connection, compressed air, all of which systems are connected with the power house, where the various pumps, hot-well, etc., are located.

The machine shop, which is 84 ft. long by 53 ft. wide and is located at the back of the long stall section of the roundhouse and connected to it by a passageway, is provided with machines for light repairs, tool room and forge with jib cranes for handling heavy parts, and a narrow-gauge push-car track between the machine shop and the roundhouse stalls.

The stores and office building is 100 ft. long by 30 ft. wide. The foreman's office is in the west end of the building and adjoining it are the booking and registering room, locker room, wash room, shower bath, etc. The oil cellar, fully equipped with storage tanks and 10 self-measuring and registering oil pumps, is in the central portion of the building. The eastern end of the building, to be used for miscellaneous supplies, is fitted with racks and shelves, and surrounded with an 8-ft. platform with ramps. This building is heated by low pressure steam supplied by the power house boilers.

The power house is attached to the back of the twelfth stall of the engine house and is 87 ft. by 44 ft. It is divided into two parts by a brick wall, the back part of which contains two 250-h.p. Babcock & Wilcox water-tube boilers which were in use in the old power house but have been re-tubbed, thoroughly cleaned and repaired. The other part contains the air compressor, feed-water, wash-out and vacuum pumps, and steam driven fan and heater coils. A hot-well is located just outside the power house for storage of hot water. This hot water is used for feed water, refilling locomotive boilers, thus affecting a great saving in fuel.

The electric current is obtained from the railway's own system developed at the Moncton shops. It is used for operating the coaling plant and motors in the machine shop, in addition to a complete lighting system throughout. The lights in the engine house are so arranged with reflectors on the posts that an abundance of light may be obtained for work on any part of the engine, but economy may be effected by turning off those not required, as each stall is supplied with separate switches.

A mechanical coaling plant of 350-ton storage capacity, equipped to elevate coal at the rate of 50 tons per hour, was installed. It is provided with three coaling tracks and one hopper track for receiving coal. It is operated by electric power from the railway system. The machinery was supplied and installed by Williams & Wilson, Ltd., of Montreal, under contract, but the construction of the building and all other work was done by the railway forces. Facilities are also provided for sand storage and supplying sand to locomotives at this plant.

Water is obtained from the city water supply and a connection with the present 9-in. main just opposite the passenger car power house, and an 8-in. cast iron pipe, 3,343 ft. long, was carried to the new facilities. A steel tank of 150,000-gal. capacity is provided as a storage reservoir. Four 10-in. standpipes are provided for watering locomotives, also connection to all buildings and facilities. The steel water tank was supplied and erected by the Dominion Bridge Co. under contract, on a concrete foundation constructed by the railway forces.

Two double track ash pits, 40 ft. long, were provided. These pits are 12 ft. deep and so arranged that they may be operated as dry or flooded pits. They are constructed of reinforced concrete walls, lined with fire brick, with the sloping wall of steel rails under the tracks. The space between the two tracks, over the deep part of the pit, is covered with a wooden platform which is removed when the cinders are being taken out of the pits. The ashes are removed from the pits by a coaling crane with a clam-shell bucket. This crane is also used to load coal from storage piles or coal engines in case the plant breaks down.

Construction of Buildings.—As all the buildings were required for operation at the same time, it was decided to carry on the construction of them simultaneously and thus prevent the work from becoming congested. For purposes of organizing a construction force, a fairly close estimate of the quantity of each class of work to be performed was made and from it an approximate estimate of the number of men and time required to perform each was obtained. By keeping in view the natural sequence of the work, a program was worked out by which the foundation work was kept well ahead of the concrete work, the concrete work ahead of the brick work, the brick work ahead of the carpentry, painting, piping, etc., and throughout the whole work there was very little interference of one class of work with another, so that a gang once organized to perform certain classes of work was kept up to full strength until the work was practically finished.

Bills of material were also prepared, orders were placed for these as early as possible and arrangements made for delivery in accordance with the general program of the work. By keeping daily records of material on hand, and by keeping the persons supplying the material daily advised of the material situation at the work, no serious delay was caused for material, although in some cases the men had to be shifted to another part of the work for a few days. This was true in the case of the steel window lintels, reinforcing for the concrete floor in stores building, pipe fittings and electrical supplies. Notwithstanding this the general program of the work was very closely adhered to.

Permanent Tracks.—During the season 7.03 miles of permanent track with 43 switches were laid. This work could not be done continuously but the layout was located on the ground, and wherever possible service tracks were laid in the position of permanent ones. A large amount of old track had to be taken up and shifted, and the locomotive crane was very useful in handling this material.

Transferring from Old to New Facilities.—It was necessary to continue operation at the old facilities until the new ones could be used. About one-half of the machines in the old shop were belt driven, and these were installed in the new shop, while the motor driven machines were left in the old shop until after the transfer had been made.

The transfer of the turntable naturally was the governing feature, this was accomplished without any interference with traffic. The table was put out of service at the old house at 8:00 a. m., Dec. 17, and was raised out of the pit without removing deck or rails, by a 75-ton wrecking crane, by a rather unique method. The crane lifted one end of the table, blocking was placed under the center, the table was then tilted over the blocking and the opposite end blocked up. By repeating this several times the table was raised high enough to permit car trucks with especially constructed bolsters to be pushed under the table. By this means the table was transferred to the new site by 4:00 p. m., where it remained till the following morning. During the night the crane was taken away on other service, and it returned at 11:00 a. m. By reversing the tilting process the table was lowered into the new pit, and at 4:30 p. m., Dec. 18, the first engine went into the new house.

Drill Steel Survey of U. S. Bureau of Standards Completed.—The comprehensive field survey conducted by the Bureau of Mines and the Bureau of Standards to determine the present status of heat treatment and breakage of rock drill steels has been completed. C. Y. Clayton and H. S. Burnholz, the investigators, recently visited the following mines: Homestake Mining Co., Deadwood, S. D.; Smuggler Union Mining Co., Telluride, Colo.; Empire Zinc Co., Gilman, Colo.; Yak Mine of the American Smelting & Refining Co., Leadville, Colo.; Cresson Consolidated Gold Mining & Milling Co., Cripple Creek, Colo.; Portland Gold Mining Co., Cripple Creek, Colo.; North Butte Mining Co., Butte, Mont.; Butte & Superior Mining Co., Butte, Mont.; Elm Orlu Mining Co., Butte, Mont.; Anaconda Copper Mining Co., Anaconda, Mont.; East Butte Copper Mining Co., Butte, Mont.; Davis-Daly Copper Co., Butte, Mont. Data were collected from these mines on heat treatment, kinds of drills and steels in use, etc. A detailed report will be sent to members of the Advisory Board and to the superintendents of the mines named. It is probable that comprehensive reports giving the results of the investigation will be issued later as Government publications, to be available to the general public.

Deterioration of Materials Used in Harbor Works

Abstract of Second Report of Committee of British Institution of Civil Engineers

From Engineering, London, June 16, 1922.

Since 1916, an important committee appointed by the Institution of Civil Engineers has been engaged in investigating the causes of deterioration of structures, partly or wholly immersed, in sea water, and in devising measures that would ensure longer life to materials subjected to such conditions. The war necessarily occasioned some delay in the active prosecution of this work, and the first report was not issued till four years later. In that report, the problem was very fully stated, the necessity for inquiry was clearly demonstrated, the available mechanism for dealing with it was explained, and the lines of investigation to be followed distinctly detailed. The committee of the Institution has now published a second (interim) report, which besides showing the progress that has been made, contains a number of abstracts from the proceedings of various committees and associations, English and foreign, indicating the interest the subject has created throughout the world. Various officials have also made reports on matters of particular interest.

Protection of Timbers.—The more efficient protection of timber was a subject in which the committee were closely concerned, and the provision of appropriate forms of preservative engaged their attention from the first. Creosote offered the most promising means of effecting an improvement, and they now report the progress made by experiments, to determine the suitability of creosote and the possibility of rendering the creosote more effective by the addition of poisonous substances. With regard to the first part of the inquiry, the committee report that specimens of timber have been purposely exposed at Accra, Auckland, Brisbane, Colombo, Wellington and Leith, and that from some of these stations have been received specimens of native timber, that had been submitted to tests with the view of determining the maximum load, the modulus of rupture, the modulus of elasticity and total deflection previous to fracture.

Of course it is as yet much too soon to draw conclusions from the systematized experiments proposed by the committee, but at Auckland observations made in timbers exposed to the attack of teredo and other pests have been continued. Some specimens of timber, 42 in. by 3 in. by 1½ in., in an unprotected condition, and others that had been protected by crude creosote and patent protectors, had been exposed in sea water up to May, 1920, but it is not quite clear how long they had been in the water when examined. All, however, were found to have been attacked by the teredo: Kahikatea, severely; Rimu and Kauri, less so, but the Oregon pine had disappeared, having been completely destroyed. Mr. Marchbanks, chief engineer of the Wellington Harbor Board, in sending specimens with description of tests states, "that the timber suitable for harbor work is getting scarce and difficult to obtain in New Zealand and that the Colony is getting more and more dependent on Australia for supplies. Under these circumstances, it is submitted that the question of the suitability of New Zealand timber for other than limited local requirements is no longer of great importance."

Studies in United States.—Other reports indicate active co-operation and eagerness to participate in the inquiry, and outside our own Colonies very material assistance is likely to come from the United States. The American Wood Preservers' Association has taken up the subject with vigor, moved to this end by the very serious loss due to the action of marine borers on the harbors of the Pacific Coast. This association has issued a report which shows that a very thorough and systematic investigation will be pursued throughout the whole length of the coast line of the United States. It appears that in past years, since 1870, the attacks in San Francisco Bay have been sporadic and varying in virulence, but in the earlier period little attention was paid to the pest, as it was believed that the quantity of fresh water discharged into the bay from the combined flow of the Sacramento and San Joaquin rivers would reduce the salinity of the water to such an extent that it would prove an unfavorable habitat for Teredo and Limnoria. This expectation apparently was not well founded, and with time the depredators have increased. It may be suggested that the enormous quantity of water drawn from the upper reaches and tributaries of these rivers for the purposes of irrigation has diminished the supply of fresh water, and has allowed the salinity at the outfall to increase to such an extent that the breeding of the teredo has been encouraged. Moreover, in recent years the rainfall has been below the normal, and it is in those years that the ravages have been the greatest. In 1917, damage to timber piling became evident, and two years later, waterfront structures in the bay erected on piles, began to fall, and in some cases whole docks were affected. Loss and insecurity became so great that the Wood Preserving Association appointed a committee to study the problem, but this committee did not begin active work till July, 1920. Previous to this date, the United States Forest Service and other agencies had made local investigations concerning the activities of marine borers and the methods for their due control. These scattered associations have now concentrated their efforts in a systematic programme, which has for its object the investigation of the entire problem, including the hydrographic, the biological and the engineering phases. The biological work carried out under the superintendence of Dr. C. A. Kofoid shows that invasions of borers are induced by the shipping traffic, and that preventive measures are an absolute necessity. The port of San Francisco has become the resort of the most widely known and most destructive representatives of the groups to which they belong. To these importations, however, California contributes, on its own account, a pest of special virulence. The Xylotrya is, however, no mean second in the competition, and though it adopts unusual habits of boring they can prove very effectual. Some of the piles in the dolphin of the Alameda Mole, driven in February, 1919, were so weakened at the mud line by the tunnelling of Xylotrya, that they had to be removed in November, 1920. Teredo navalis can accomplish 4 in. penetration in as many months, and is a foe to be respected. Among the crustacean borers is the Limnoria Lignorum, a species which acquired considerable notoriety in the last report, and whose ravages are very destructive since they often complete the work of the teredo.

Protection of Piling.—The recommendations submitted to the committee for coping with the destructive work of these organisms seem hardly adequate, but time will be required to determine their efficiency. It is proposed to restrict the uncontrolled use of untreated or unprotected timbers in marine structures, to remove by State or Federal sanction all old, unused, infected marine structures, and to prevent harbors being used as a dumping ground for waste wood. As a protection to piles it is proposed to use bark, metal sheathing, and paints of various kinds. Some forms of concrete protection are described, and among these the Koetitz pile is in favor. This pile is formed by slipping over an untreated wooden pile, a previously made reinforced concrete cylinder and driving the cylinder into the mud, the space between the wood and the concrete then being filled with sand or grout. Some of the suggestions appear rather bizarre than practical. Among the more fantastic is the proposal to explode dynamite in the water round the piles in the hope that the concussion would destroy animal life. This plan has been tried by the ingenious, but like the plan of electrolysis of the water, liberating chlorine gas, supposed to be fatal to the teredo, it has proved futile. Another arrangement suggested by the study of the habits of the borer was to construct the pile of separate planks, spiked together, so as to present from any direction the greatest possible number of cracks in order to intercept a continuous path through the pile, the belief being that the shipworm could not cross a crack. But whatever the scruples of the shipworm may be, it soon became apparent that Limnoria had none, and the plan proved to be one adopted to afford shelter rather than discouragement to intruders.

Life and History of Marine Borers.—Such experiments show conclusively the need for obtaining more precise knowledge of the life history and habits of the marine borers. The committee early recognized this necessity, and selected Plymouth as a suitable site for experimental work, since the laboratory of the Marine Biological Association would be available. The investigation was intrusted to Dr. G. Barger, and Mr. C. R. Harington, the latter of whom experienced great difficulty in finding either the teredo or the evidence of its work. The reasons assigned for its absence are interesting, as they support the early views of the biologists at San Francisco, where the conformation of the coast line is similar. Mr. Harington ascribes the absence to the variations in salinity due to the inflow of fresh water and interference with the free tidal wash, which in its turn affects the quantity and character of the food supply. At Exmouth, where the docks are far up the estuary, it might be expected that teredo would be absent for the same reason, and this is the case, but at Falmouth, where the inflow of fresh water is slight and the tidal wash unimpeded by a breakwater, teredo are abundant. The observed conditions point to a possible way by which the pest might be eradicated, and the process would be a repetition of that already adopted at Hartlepool, where fresh water is periodically pumped into the timber ponds to preserve the timber intact. Evidently the degree of permissible salinity must be determined experimentally, and unfortunately owing to the want of a proper supply of food, Mr. Harington was not able to bring vigorous cultures of the free-swimming larva to the stage when they attack wood, but experiments in rearing spawning teredo in water in which the salinity was varied from 35 per cent to 5 per cent showed that the lowest the limit at which the larva could swim with ease was about 20 per cent. A lower percentage would probably suffice under natural conditions where the wash of the tide tended to keep the mollusc alive.

Impregnating Timber with Poisonous Substances.—Another possible form of riddance which has engaged the attention of the committee is to impregnate the timber with some poisonous substance. It appears not impossible but that ordinary creosote contains some substances toxic to teredo, but these constituents of creosote are soluble in water, and are therefore soon washed out of the wood. To make the practice successful it is necessary to find some toxic substance soluble in creosote, but insoluble in water. A difficulty is here presented because the toxicity in sea water is difficult to measure, on account of the slight solubility which is essential to the problem. In some experiments with concentrations of 1:10,000, the soluble limit of the chemical employed was passed, the substance therefore remained partly in suspension and rendered the test unsatisfactory.

Certain chemicals were found to be decidedly toxic on Saxicava, Mytillus and Limnoria, and to fulfill the conditions of insolubility in water. A substance containing arsenic and used in gas warfare seemed specially suitable, and more poisonous to teredo than the tar acids of creosote. As a crucial test it was proposed to dissolve the poison in boiling creosote and to soak pieces of dried deal in it for three or four days, when a fairly even impregnation to the depth of half an inch could be obtained. Impregnation of harder woods was not attempted in this preliminary inquiry. The prepared pieces of timber with others treated with creosote, and also untreated timber, were exposed in suitable localities and examined last Christmas, but only the untreated controls were attacked slightly by Limnoria. Either the specimens were not exposed long enough or they were put out too late in the season. The experiments will be continued next year. It is not impossible, as some of the experiments seem to show, that the boring organisms possess different degrees of immunity to poisons and of indifference to creosote. In a piece of creosoted timber from which the preservative had been washed out, it was noticed that while the attacks of limnoria were confined to that part of the wood free from the creosote, the burrows of teredo penetrated into every part with apparent impartiality.

In the first report issued by the Committee it was shown that the denser and more resisting kinds of timber, which, like greenheart, resist teredo attack, with great success are very difficult to impregnate, and Dr. Barger is continuing experiments to determine the best method of injecting poisons in such cases. Some of his prepared specimens are exposed at Lowestoft, where the water is very much infested with various pests. Steps, too, are being taken to send similar specimens to tropical parts where the boring effects are more rapid and more destructive. It must be remembered, however, that in any case, the toxic effect of the prepared materials cannot be expected till the unpoisoned creosote controls have been attacked. With regard to greenheart, of whose endurance many instances were given in the last report, Dr. Barger, with the view of determining whether the immunity was due to its texture or its chemical composition, has had a considerable quantity of greenheart sawdust extracted by alcohol, by chloroform, and by dilute ammonia. It was found that the alcoholic extract contained an alkaloid corresponding to bebeerine, previously found in the bark, and it is proposed to have test pieces of timber impregnated with alcoholic solutions of the alkaloid, and other constituents, and also with synthetic chemicals in suitable solvents, other than creosote. The intention is to trace the action of the alkaloid upon the larval and adult teredo, with the view of ascertaining if the timber in question can by this means be rendered immune from attack.

Concrete in Marine Structures.—With regard to the power of concrete to resist the action of waves, frost, and marine organisms the committee add reports on the deterioration of structures exposed to sea action. Mr. L. H. Savile treats the subject generally from the Admiralty point of view, and Mr. T. B. Hunt and Mr. G. P. Hayes deal in detail with the harbors of Portsmouth and Devonport, respectively. At those places the materials have long been exposed to sea action, and the experience gained is sufficient to enable some practical conclusions to be drawn, so far as Admiralty works are concerned. Mr. Savile insists upon the necessity of rendering the concrete impenetrable by sea water, for the percolation through the interstices will inevitably lead to destruction.

The action of the weather above high water level is also particularly noticeable in ferro-concrete structures. The vast majority of rust spots occur in this position, and particularly on the under side of beams where, through faulty workmanship, the stirrup has dropped in the mould during concreting. The Admiralty is emphatically of opinion, that in exposed positions the least cover for reinforcement should not be less than 1½ in., and preferably 2 in., in order to allow for those practical exigencies which are inseparable from normal experience. The pounding action of the waves cannot be avoided, and good workmanship is usually sufficient protection, but the thrash of wave-borne shingle and sand may cause deterioration against which it is difficult to provide an adequate remedy. It is suggested that since air-dried concrete is the stronger and more reliable form, a desirable course of construction would be to prepare concrete in mass, or blocks, on land and transport these to the site. In a more detailed report on Devonport Dockyard, Mr. Hayes states that ferro-concrete has been satisfactory, and has withstood the action of sea organisms where the matrix has been of good quality and homogeneous throughout; but where the cement has been insufficient deterioration is rapid. Instances are given to show that piles erected sixteen years ago exhibit no signs of wear, and when the surface is broken by abrasion the interior is clean and hard, with externally very few rust spots. On the other hand, a land pier constructed of ferro-concrete in 1911 shows extensive signs of deterioration, owing to the mixing not having been continuous throughout. Fairly large pieces of the surface have broken away, exposing a very soft interior, the grains of quartz being quite free of any mortar. Further, there are many rust spots.

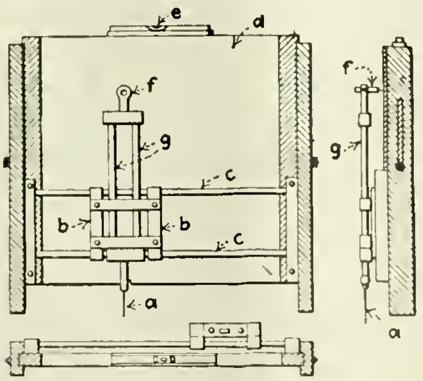
These reports show generally that the materials are apt to be better than the workmanship, and it is doubtful if the best results have yet been secured. This conclusion is supported by reports from the Bureau of Standards of the United States Department of Commerce, dealing with the structures of the Navy Yards of Boston and Puget Sound. The aim of these reports is to show how trouble can be avoided, and to insure the production of more durable work. One point insisted upon in an emphatic manner is the rapid deterioration caused by the use of too little, or too much, water in mixing the ingredients. Attention is also directed to the chemical disintegration of concrete both in hot and cold climates, and the need for radical modification in the design of reinforced concrete work in marine structures.

One great difficulty in completing these experiments is the length of time necessary for the completion of adequate tests under natural conditions, but at Boston where the variations of exposure are very severe, an experiment on the effect of varying the amount of water in concrete has been unintentionally carried out. In one of the piers, concrete of three different consistencies has been accidentally employed, and the conditions of that section of the structure where the cement and aggregate have been mixed with a medium amount of water are decidedly superior to the remainder. What other conditions may have obtained since erection are not known, but experiments are still being carried on at Boston by a private company, on a large scale. Mr. Bakenhus reports the results of a seven years' test of 24 concrete specimens, each 16 ft. in length and 16 in. square, cast horizontally and suspended vertically. Each weighs from 4050 lbs. to 4350 lbs., and is moored in such a way that the lower end is continually immersed in the sea, the upper end occasionally, and the central portion is subject to the alternate action of air and salt water. The composition and mixing are varied, the object being to test the effect of wet and dry mixtures, rich and lean mixtures, the use of special brands of cement, admixture with hydrated lime, addition of patents, etc. The monoliths are examined at intervals of a year, and the following conclusions have been accepted by experts. That the use of sea water in mixing is not injurious. That the substitution of 10 per cent of hydrated lime for an equal quantity of cement favored an earlier and more rapid erosion. That the addition of soft soap and powdered alum (a recommended patent) was decidedly harmful, and that 5 per cent of clay added to the cement exercised a beneficial effect on the concrete.

The third material upon which the committee proposed to experiment was steel; and Sir Robert Hadfield reports that the preparation of the whole of the specimens intended for exposure at the various stations had been completed, and some of the consignments have been dispatched. Dr. J. Newton Friend has made himself responsible for the weighing, marking and identification of the various bars. The specimens are divided into four sections, I, Irons (rolled and forged); II, carbon steels with varying percentages of manganese, sulphur and phosphorus; III, special steels including a 13.50 per cent chromium steel ("non-rusting" steel); and IV, hot and cold blast cast-iron. About 80 bars of dimensions 24 in. by 3 in. by ½ in. of each material have been prepared, a total in all of 1,330 bars.

Device for Determining Wear of Rails and Car Wheels

A home-made apparatus for obtaining rail and car-wheel scribings, designed by Albert L. Donnelly, Division Engineer of the Connecticut Co., is described by Joseph E. Rapuano, of the Maintenance of Way Department, in a recent issue of the Electrical Railway Journal. As shown in the accompanying illustration, reproduced from the Journal, the device consists of a metallic needle, a, mounted upon a carriage, b-b, which can move upon the metallic slides, c-c, which in turn are secured to the wooden frame d. One end of this frame is equipped with a level tube, e. The paper upon which the scribing is to be outlined is tacked upon the wooden frame underneath the pencil f. In operating the instrument the needle is carefully made to pass over the surface to be outlined by a slight pressure upon the needle which is guided by the hand of the operator. As the needle passes over the surface of the rail or wheel, its horizontal motion is governed by the carriage sliding on the metallic slides c-c while its vertical motion is controlled by the rods g-g, which slide through holes in the carriage b-b. At the same time the pencil f records the outline in full size and the operation is complete.



Arrangement for Determining Rail and Wheel Contours.

Training Young Engineers in Railway Maintenance Work*

It is desirable that engineers in the maintenance department be graduates of some good technical school, but these positions, however, should not be limited to graduate engineers. To limit these positions to graduate engineers would in many instances drop the bars against young men who display ambition to follow engineering. When on account of finances young men are unable to take a full course at an engineering university, and study engineering with some good correspondence school or university extension course, they deserve consideration. Such men understand that their success depends upon their obtaining the necessary knowledge of their profession. The engineer who is obtaining his theory by private study should have as good knowledge of the theory of his profession as his more fortunate co-workers who have had the advantage of a college course. There have been numerous cases where university graduates were unable to make practical application of their knowledge, and we do not think we should exclude from consideration the man who obtains his theory by other means.

Every railroad organization has its own ideas and methods on the education and training of young engineers for positions of greater responsibility. It should, however, be possible to agree on a selection of these for general use.

Good results may be obtained by carrying on an educational campaign through periodical meetings for the purpose of exchanging views through the medium of papers, reports and discussions. This can probably be best brought about by organizing an association modeled somewhat along the lines of the A. R. E. A. Membership should be offered all officers above the ranks of supervisor of bridges and buildings, supervisor of track, supervisor of water service and supervisor of signals, including assistant engineers in the maintenance of way department. This association should appoint committees following, as far as possible, the same line of research work as done in the A. R. E. A., modified as local conditions might suggest.

The young engineer should be required to study and thoroughly familiarize himself with standard plans and practices, with maintenance of way reports, and with the rules, general instructions, etc., governing the maintenance department. He should also be encouraged to familiarize himself with proceedings of the A. R. E. A. and recommended practices of their Manual. It should be the endeavor to arouse and sustain the interest of young employes by explanations of work assigned, in order that they may be able to appreciate the relation of their particular work to the general maintenance scheme.

An incentive should be offered employes to work by encouraging them to take additional responsibilities. Every man should be trained for the next higher position. Probably the best method is to rotate the field and office work, if possible, showing a man his mistakes immediately upon completion of each assigned job. The young employe should be encouraged to study maintenance methods from the standpoint of economics, with the idea of developing an analytical viewpoint—a valuable asset in maintenance of way work.

There should be practiced a systematic rotation of service for the members of the engineering corps, to include surveying and field work, masonry inspection, building inspection, supervision of construction and work in drafting and designing. After the young engineer has had sufficient experience in office and field work, he should be transferred to a position which will give him experience and training in the handling of men and practical maintenance work.

A fixed minimum engineering corps should be maintained throughout the year with definite lines of promotion, to the end that the employe will have an incentive to continue in the service of the railroad company.

The young engineer should be required to attend division staff meetings and take part in discussions, thereby becoming familiar with the various operating matters discussed.

The division engineers, or corresponding officers, should take a personal interest in the education and development of young engineers, taking them over the road as frequently as the opportunity presents itself on their inspection trips, discussing with them the various features of the work they come in contact with, encouraging them to ask any questions and offer any suggestions that might occur to them, thereby broadening their views on the general conduct of maintenance work.

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*A sub-committee report of the Committee on Economics of Railway Labor of the American Railway Engineering Association

It is believed the position of supervisor of track, supervisor of bridges and buildings, supervisor of signals and inspectors should be filled from the engineering corps on an equal footing with other employes.

Efficient Thawing of Frozen Gravel with Unheated Water

Information regarding the use of water at natural temperatures in the thawing of frozen gravel in placer mining operations is given in Technical Paper 309, by Charles Janin, consulting mining engineer, just published by the United States Bureau of Mines.

Experiments in cold-water thawing demonstrate that under favorable conditions the process is an assured success. It is proving of great value to the gold-mining industry of Alaska and the Yukon Territory and is encouraging investigation and exploitation of areas of frozen gravel that had been considered of too low grade for profitable mining.

In placer mining in the far North one of the greatest difficulties encountered is the permanently frozen condition of the ground. In the early days of mining the ground was thawed by the primitive method of building wood fires on the surface, at the bottom of a shaft, or at the face of a drift. Although this method was slow and costly, a more effective one was not discovered until about 1898, when it was noticed that the steam escaping from the exhaust of a hoisting engine had thawed a hole in the solid "muck." Further experiments followed, and the direct application of steam through points proved so effective that it became the chief method adopted in thawing many millions of cubic yards of gravel for drift, surface mining, and dredging operations.

Tests with hot-water thawing were made at different times. Experiments indicated that ground could be thawed by this method, but in comparison with steam thawing the latter was generally found more effective. At all events, no extensive thawing with hot water was ever done.

In all, many millions of cubic yards of frozen ground have been mined in the northern fields of Alaska and the Yukon Territory, as well as Siberia, by using various methods to soften or thaw the gravel. The most satisfactory method developed was thawing with steam points. This method, however, proved slow and costly under the most efficient management, its cost amounting in general to about 40 per cent of the total cost of mining, and at some mines to perhaps 70 to 80 per cent. The high cost of thawing required that the gravel mined contain a much higher gold content than ground that could be profitably mined where thawing was unnecessary, and prevented the working of the lower-grade ground in the frozen areas.

The working of most of the deeper frozen or partly frozen ground seemed economically impossible except where drift mining would be profitable. A number of gravel areas in the Far North have attracted mining men because of the high gold content as compared to dredgable areas of unfrozen ground in other districts. Little attempt to work much of this gravel has been made until recently, however, as no cheap method of thawing was known. Experiments have been made from time to time since the beginning of placer minning in the Far North with the purpose of developing a more efficient method of thawing the frozen ground, and the files of the Patent Office show drawings of some peculiar machines designed for that purpose.

About 1915 to 1917, different persons started experiments on an entirely new plan for thawing the frozen gravel. Water at the natural summer temperature was applied by drilling holes through the frozen muck and gravel to bedrock and the water was allowed to find its way through the gravel back to the surface. This water was taken from surface ditches, or through pipes under pressure, or pressure was obtained by pumping. The results of these tests were very satisfactory.

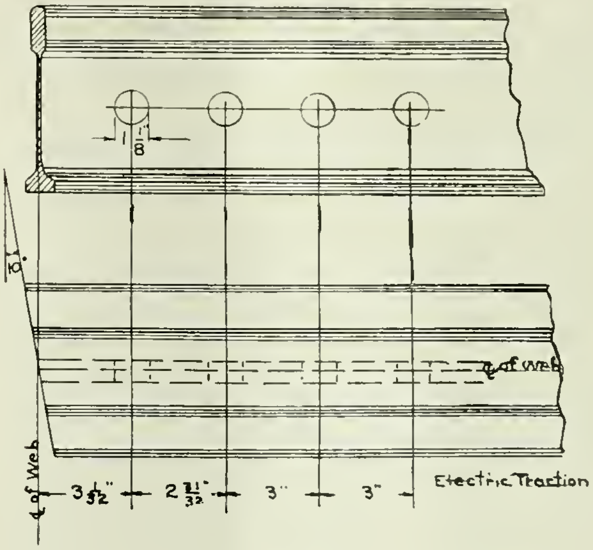
Although there is still much to be learned regarding practical application of the method, thawing with cold water has passed the experimental stage and is being proved of great value to the gold-mining industry.

The successful application of this method where water is obtainable under pressure without pumping will make large areas of so-called low-grade ground available for dredging, and ground that has previously been considered to be of little or no value will now be of economic importance. Had the knowledge of this method of thawing been available to the Yukon Gold Co. and other companies operating dredges in the Far North during the past 10 years, there might have been a considerable saving in costs and a correspondingly additional profit to those companies.

A resume of experiments in cold water thawing conducted in Alaska is given in Technical Paper 309, copies of which may be obtained from the Bureau of Mines, Washington, D. C.

New Mitered Rail Joint for Cleveland Street Railways

A new type of rail joint has been devised and installed in the Cleveland, O., railways, by Charles H. Clark, Engineer of Maintenance of Way. According to Electric Traction the joint is mitered at an angle of 10 degrees with the idea of reducing the pound as wheels pass over the joint. By reducing the pound it is also believed that the cupping of rails at the joints will be greatly reduced and a smoother riding track will result, with greater life to both rail and equipment.



Electric Traction

Detail of Rail for Mitered Joint.

In addition to the mitering, the new joint also has several novel features. As a base plate, a section of channel iron is utilized. The channel has the legs flattened at each end where it rests on the joint ties. The rail is welded to this channel base plate. Eight-hole joint bars are used, the drilling being as shown in the accompanying drawing. As is standard practice on the Cleveland Railway, the joint plates are seam welded to the rails, the welding being continuous along the top of the joint bars and extending along the bottom of joint bars from the ends toward the center but omitting a section each side of the point where rail ends meet.

Another feature which is being utilized in new track work in Cleveland is the canting of rails. The amount of cant given the rails is 1 in 25.

Average Freight Hauls.—No reliable records are available as to the average haul in the early period of our railroad building but it was necessarily short on the very large bulk of the commodities transported. The following from the report "Transportation" of Joint Commission of Agricultural Inquiry indicates the growth in this direction: The statistics for 1900 show an average haul for freight of 238 miles, and this had grown to an average haul of 326.2 miles in 1921. This clearly demonstrates the ever-widening range of distribution, which is brought about by the demands of the people for products from far distant points.

Underground Hygiene and Sanitation

Safe Practice for Mines and Tunnel Work Outlined in Paper Presented at Detroit Meeting of National Safety Council

By R. R. SAYERS,
Chief Surgeon, U. S. Bureau of Mines.

The terms "sanitation and hygiene" are often used interchangeably, but it is more usual to apply "sanitation" to the environment or surroundings, and "hygiene" to the individual. The subject, however, is so broad that only a few of the phases of sanitation will be discussed in this paper, while the various phases of hygiene will be deferred for later consideration. One of the best definitions of sanitation that I have heard was given by Dr. L. L. Lumsden, of the U. S. Public Health Service, who stated that "sanitation is the common-sense application of the principles of cleanliness."

As stated above, this paper is limited, and only the following phases are considered: (1) Safe practices with drinking water; (2) safe methods of sewage disposal; (3) safe practices in ventilation.

DRINKING WATER.

Pure drinking water may be defined as that which does not contain any substance injurious to the health. The purity of drinking water underground is dependent on its freedom from contamination (1) at its source, (2) during distribution, and (3) by the users.

Contamination at Source and Purification.—The most satisfactory drinking waters are clear, odorless, colorless, have no or very low mineral content, are well aerated, and are free from bacterial contamination. Turbidity is due to fine particles of solid matter suspended in the water. Kober states that 50 parts of solids per 100,000, or 30 grams per gallon, render the water unfit for drinking purposes, as such water is irritating to the gastro-intestinal tract. Some dissolved minerals, as the sulphates of sodium and magnesium, may cause the water to have a cathartic action; other minerals may be irritants, as acid waters; or poisonous, as those containing lead or zinc salts. Though unaerated water is not detrimental to the health, its taste is flat and, therefore, not so pleasant to drink.

Bacteria are probably the most frequent contamination of water detrimental to health. Water is often polluted with sewage, human excreta, animal waste and household waste. Water containing bacteria indicating contamination with any of the above wastes should be purified before it is used for drinking purposes. Properly distilled water is ideal from a hygienic standpoint, but it is expensive to produce and its taste is flat. Thorough aeration improves the taste but adds to the cost and may add organic matter, including bacteria. Boiling renders water safe as far as bacteria, true toxins, and probably most substances of organic origin are concerned. However, the ill effects due to stable inorganic chemical matter, such as lead salts, are not eliminated by boiling. This method of purification may be used where the water is known to be infected or where its character is unknown. Boiled water should be stored in covered pails or stoppered bottles in such a manner as to avoid contamination.

Small filters, such as household filters, have a very limited use. They remove turbidity by straining out the solid particles, but reliance should not be placed in them if the water is infected and if they are operated in the usual way. It is said that even in the closest grained, unglazed porcelain the pores of the filter are larger than the bacteria. The bacteria do not get through on account of the tortuous passages, but if conditions are favorable bacteria may grow through the walls of the filter and sometimes thus contaminate even pure water passed through them.

One of the most convenient methods of purifying water is by the use of chlorinated lime (bleaching powder). For treatment of water on a small scale a stock solution should be made by mixing a teaspoonful of fresh chlorinated lime with one quart of water. Use one teaspoonful of a stock solution to 10 gal. of the water to be treated—36 drops to 1 gal.—mix, and let stand at least 15 minutes before using. The stock solution should be kept in a well-stoppered bottle in a cool place.

The discussion of purification of large amounts of water, as for a community, has been omitted, since such treatment should have the supervision of competent sanitarians; it has been demonstrated many times that haphazard methods usually lead to disappointing results.

All drinking water supplies for underground use should be properly disinfected (chlorinated) unless they are obtained from a source that has been approved by the State Department of Health.

Contamination During Distribution.—The safest method of distributing drinking water is to pipe it from its source to convenient points for use underground. While this is the safest method, the use of containers, such as kegs, barrels, or tanks, is probably the most widely practiced method, and is satisfactory for many mines, but it requires constant attention to prevent contamination of the water. All containers should be carefully washed and sterilized at least once a week when the source of the water is known to be pure, and daily if the water is infected or its purity unknown. An easy and efficient way to sterilize these containers is to add ¼ ounce of chlorinated lime to a 50-gal container, or a proportionate amount for containers of other capacity; fill the container with water and allow the mixture to stand from four to six hours. All containers should be so constructed that they may be kept tightly closed, and so arranged that the water can be drawn only from a tap or drinking fountain, or both.

Another method practiced at many mines is for each underground worker to carry drinking water in an individual pail. This method may be commended in that usually only the one man drinks from the pail and thus the opportunity is lessened for the spread of disease. The principal objections to it are the difficulty in determining the purity of the various sources of water, and the lack of supervision in maintaining their purity; also the limited amount of water available to each man for his working shift. The objections to this system can be lessened by placing a drinking fountain and faucet on the surface near the entrance to the mine, and in the case of metal mines by placing a drinking fountain and faucet on each level where the water has been piped into the mine. In case the water is taken underground in containers, such as barrels, the containers should be equipped with a drinking fountain and faucet of approved type. The miners can then conveniently fill their pails at these faucets from a source whose purity can be determined and controlled by the mine management. It also gives the miner an opportunity to have a plentiful supply of water. However, to secure the best results, a sufficient number of containers must be available in order that they may be placed convenient to all working places.

When it is advisable or necessary to cool water with ice, it is safer to so construct the containers that the ice does not come in contact with the water being kept cool. Where this is impracticable and the ice is placed in the water, it should be clear natural ice, ice made from distilled water, or ice made from a source approved by the State Department of Health.

Contamination by Users.—The common drinking cup is known to be capable of the transmission of disease from one user to another, and should be abolished; drinking fountains or individual cups should be substituted. Drinking fountains are more practical, but should be so designed that it is impossible for the mouth of the drinker to come in contact with the outlet. This can be best accomplished by having the jet of water projected at an angle to the vertical. A metal guard about the outlet is also advisable. Suitable drinking fountain heads may be procured from manufacturers, or made in the local machine shops. One so made was described by Mr. C. B. Yates, of the Homestake Mining Co., at the meeting of the Congress of the National Safety Council last year. Mr. Yates called attention to the fact that the Homestake company had discontinued the use of bowls on the head of the drinking fountains as they soon became foul with dirt and tobacco. The waste water should fall freely from the jet into a drain pipe.

Where the water is carried underground by each miner in an individual pail, there is less danger of infecting the water, as usually only the one miner drinks from the pail; the pail system may be used in conjunction with the distribution of water by pipes or large containers, since it is practically an individual cup system.

Summary of Safe Practices with Drinking Water.—Water for drinking should be obtained from a source known to be pure. To be assured that it is pure, it is advisable to have the water or the sources of water examined and approved by the State Department of Health.

Where the water is known to be infected or its purity is unknown, it may be made safe for drinking purposes by distillation, by boiling, or by chlorination.

Small filters of the household type are not usually satisfactory and their use is, therefore, not advised.

The piping of drinking water underground is the safest method of its distribution.

If containers, such as barrels or kegs, are used in taking water underground, they should be kept tightly closed with only a tap or drinking fountain head, or both, for withdrawing the water. Such containers should be washed thoroughly and disinfected at regular intervals, at least once each week.

Sanitary drinking fountains should be so designed that it is impossible for the mouth of the drinker to come in contact with the outlet. Those fountains which direct the jet of water at an angle with the vertical are usually most satisfactory.

Taking drinking water underground in individual pails usually has the disadvantage of the water being obtained from many sources, often of unknown purity, but it has the advantage of decreasing the danger of transmission of disease through drinking water, as each miner generally drinks only from his own pail.

Where ice is used for cooling water, it should be made from distilled water or water from a source approved by the State Department of Health. In cooling the water the ice and water should not be in contact, in which case the purity of the ice is of less importance.

SEWAGE DISPOSAL.

The disposal of sewage is an important item of underground sanitation. It can best be emphasized by reviewing some of the dangers from its improper disposal. Miners who have been farmers know that livestock kept in the same pasture for many years, especially if the pasture is small, do not thrive, particularly in warm, moist climates. Nearly all animals have parasites in their intestinal tract. The eggs of these parasites are passed in the droppings, develop into young worms, and, in turn, reinfect the livestock. Young stock usually sicken more easily and sometimes die. These facts apply in a similar manner to man. If his hands, food, or drinking water become contaminated with human sewage, he is often infected, sickens, and sometimes dies as a result.

Underground Methods of Sewage Disposal.—Underground toilets should be so designed as to prevent the spread of disease germs contained in human excreta. The receptacle for the feces should be such that their spread by any or all agents, as flies, mice, rats, water, is avoided. The toilets should be in a well-lighted location convenient to the workers, and their surroundings should be kept clean, the roof and walls being whitewashed. They should not be allowed at any time to become a nuisance either as to cleanliness or location. Dr. W. C. Gorgas, former Surgeon-General of the U. S. Army and Chief Sanitary Officer of the Isthmian Canal, recommended a small vault for mines on the Rand. He stated that he would use no water whatever, but emphasized the importance of fly-tight covers. Recently a mine superintendent, who was at one time a sanitary engineer, told me that he intended installing a water-tight system in his mine with a disinfectant to make the contents sterile.

There are several disinfectants in use, each having its advantages and disadvantages. Lime is a very cheap disinfectant, and is cleanly and easy to handle. However, its disinfectant efficiency is low and it must be used liberally to be at all effective; all excreta must be covered complete at all times. Chlorinated lime, while effective for killing bacteria, must be used in sufficient amounts to allow for oxidation of organic matter. Furthermore, hookworm eggs are very resistant to the action of chlorate of lime. It has been shown that from 22 to 40 hours' exposure fails to kill them. The use of chlorate of lime is, therefore, not recommended where hookworm is known or likely to exist. Cresol or tricresol or other disinfectants of this group have been found satisfactory if used in the strength of one part solution to 19 parts of water. Caustic soda (sodium hydrate) in a 1 per cent solution destroys all bacteria, but a 3 per cent solution is required to destroy hookworm eggs. This chemical is an excellent deodorant and disinfectant, but a mechanical agitator is necessary for its efficient action. In the use of any of the disinfectants where percentage strength is given, sufficient quantities should be used to provide for that percentage when the receptacle is full.

Water-tight cans as receptacles have been found to be satisfactory in many mines when properly cared for. These cans may be made of 18-gage galvanized iron reinforced at the top and bottom with 2-in. iron bands. The cans should be 16 in. high and 16 in. in diameter; the corners inside should be rounded and a removable cover provided. A removable handle, or two attached handles, have proved satisfactory. The New Jersey Zinc Co. have designed an all-metal latrine with a removable seat of aluminum which has no seams or curves. When a clean can is brought into the mine to replace the used one, the removable handle and cover are taken from the clean can and placed on the used one, which is then ready for transportation.

To prevent the access of flies, mice, rats or other small animals to the contents of a toilet can, it may be placed in a box of special design with tight joints of sound lumber, not less than 1 in. thick and dressed on one side. It should be provided with a closely fitting lid, the seat to be covered with a self-falling hinged lid. A box for a single can should not be less than 20 in. wide, 22 in. long, and 16½ in. high—inside measurements.

Toilet cars are another type of sanitary toilets for underground use. These mine toilet cars should be made of about 3/16 in. steel about 4 ft. long, 2 ft. wide, and 2½ ft. deep. There should be no sharp corners or projections inside the car, thus lessening the opportunity for excreta to adhere to the sides of the car. Such a car as described is usually provided with two seats.

Practical experience has shown that sewage disposal systems need regular attention if they are to remain sanitary and satisfactory. One man should be assigned to the duty and the care of the toilets should be made at regular stated intervals. These intervals will vary from daily attention to once in several weeks, depending upon the type used, the disinfectant provided and the number of miners served.

Surface Sewage Disposal.—The effect on underground sanitation of the proper facilities for sewage disposal on the surface should be borne in mind by all operators. The surface toilets should be placed in convenient, clean, well-lighted, comfortable surroundings. Water-carriage sewage systems are, of course, the most satisfactory. Mines having modern change houses should include sanitary toilets as part of their equipment. When toilets of the above type are so located, their regular use by the miner follows naturally. This lessens the amount of sewage underground and encourages regular habits that are important to the health of the miners.

Summary of Safe Methods of Sewage Disposal.—Improper or careless methods of sewage disposal underground predispose to the spread of intestinal disease, notably typhoid fever, dysentery, hookworm disease, and other parasitic infections.

Water-carriage systems for the disposal of sewage underground are impracticable in most mines.

Water-tight and animal-tight containers for toilets are advised.

It is advisable to use a disinfectant in all containers; caustic soda, cresol or tricresol, and similar disinfectants have proved satisfactory.

The toilets should be conveniently located, well-lighted, and the surroundings kept in a sanitary condition.

Mine toilet cars have been used in many mines and found satisfactory.

All systems of sewage disposal need constant attention if their operation is to be satisfactory. One man should be made responsible for their care, and such care should be given at regular, stated intervals.

Adequate, convenient, sanitary surface toilets should be provided at all mines.

VENTILATION.

Pure dry air at sea level contains 20.94 per cent of oxygen, 78.9 per cent of nitrogen, 0.94 per cent argon, and 0.03 per cent of carbon dioxide. Mine air may vary from the above composition owing to depletion of oxygen, increase in carbon dioxide, and to the presence of abnormal gases as methane, hydrogen sulphide, and carbon monoxide, and to the presence of various dusts, such as those coming from coal, ores, and rock.

Effects of High Temperatures and Humidities.—Even though the air be of normal composition, if the temperature and humidity are abnormally high the efficiency of the miner is materially decreased, and there is probably a deleterious effect upon the health, for experience shows that cases of heart disease and vasometer instability stand hot atmospheres badly.

Sayers and Harrington in their studies have noted particularly the effect of air movement and have found that, if the air temperature is above 75° F. and the relative humidity is high, the efficiency and comfort of a worker are increased materially by air movement. With a linear movement of 100 ft. a miner is comfortable and fairly efficient as long as the temperature is not above 85° F., wet bulb. The same is true when the temperature is between 85° and 90°, provided the air velocity is 200 to 300 lin. ft. per minute. With a temperature of 90° to 95° the air is very oppressive when still, but it is not especially so when it has a movement of 400 to 800 lin. ft. per minute.

Good ventilation has been shown many times to increase the efficiency of the miner working in such hot places. Many mining companies have installed and are installing ventilating systems to lower the temperature. One large mining company spent about $70,000 in sinking a ventilating shaft and in purchasing ventilating equipment. They report that this installation pays for itself once every six months in savings and in the increased efficiency of the workmen. In recent studies it has been shown that the efficiency and comfort of the miner could be materially increased in high temperatures and humidities by the use of a small portable fan to obtain air movement. This method, however, should be used only in emergencies and as a temporary expediency, because the final solution of the problem is the permanent installation of a ventilating system which will replace hot, humid air with cooler pure air, and thus prevent the abnormal accumulation of harmful gases.

It cannot be emphasized too strongly that efficiency, comfort and good health are dependent to a large extent on pure air, and that ill effects or symptoms arising from variations in the composition of the air, caused either by the lowering of the oxygen or by the addition of gases, such as carbon monoxide, or carbon dioxide, are best treated as follows:

1. By getting the victim to pure, fresh air in the quickest time possible.
2. By breathing pure oxygen, if available.
3. By using Schaefer method of artificial respiration when the victim has ceased to breathe or is breathing slowly, irregularly, and shallow;
4. By keeping the victim warm and at rest.

Summary of Safe Practices in Ventilation.—Miners who work in mines in which the rock contains a high percentage of silica and use dry mining methods have been found to be prone to pneumoconiosis.

Miners' phthisis or pneumoconiosis has been found to predispose to tuberculosis.

Good ventilation, wet drilling, and wet mining methods materially lessen the amount of pneumoconiosis.

Physical examination at regular intervals, at least once a year, followed by proper precautions by those found to be affected with pneumoconiosis or tuberculosis, materially lessens their prevalence.

Some dusts, as those from the more soluble lead, zinc, or arsenic ores, may cause illness due to the toxic effects of the respective salts of these metals. The precautions mentioned in Paragraph 3 are applicable here.

Air low in oxygen causes deeper and more rapid breathing and in increase in heart rate. If sufficiently low, unconsciousness and even death may result.

The flame of a safety lamp may be used to detect air deficient in oxygen.

Increased percentages of carbon dioxide in air cause an increase in the depth and rate of respiration, headache, dimness of vision and tremor.

Carbon dioxide may be detected and the amount present determined by a special portable apparatus developed for this purpose.

Nitrogen, hydrogen and methane have no toxic effect upon the body, but may act as diluents of oxygen and thus indirectly cause the effects of oxygen deficiency.

The flame of a safety lamp, or a Burrell detector, may be used to determine the presence of marsh gas.

Hydrogen sulphide and sulphur dioxide may occasionally occur in mines in sufficient quantities to be dangerous. In low concentrations they cause irritation of the eyes and respiratory organs.

The presence of hydrogen sulphide and sulphur dioxide may be detected by their respective characteristic odors.

Carbon monoxide (white damp) has caused the death of many miners.

The presence of carbon monoxide may be detected by its effect upon canary birds or by the use of a carbon monoxide detector.

Animals without red blood are not affected by carbon monoxide.

High temperatures and humidities decrease the efficiency of miners and probably have a deleterious effect upon their health.

Good ventilation will prevent the ill effects of all gases referred to above.

Air Bell Proves Economical for Completing Excavation and Concreting for Bridge Pier

An air bell was used in the construction of one of the new piers for the Baltimore & Ohio R. R. bridge over the Allegheny River at Pittsburgh, Pa.

The conditions which led to the use of an air bell were unusual. The depth from pool full to river bottom at this pier, was about 12 ft., and the underlying soil consists of 4 ft. of sand and gravel, under which is a layer of shale or sandstone. With the object of reaching a sandstone foundation, the site was dredged to a depth of 18 ft., and a coffer-dam was constructed of a single row of interlocking sheet piles which enclosed the pier and the adjacent area. The area inside the coffer-dam was dredged within 1 ft. of rock, and the excavated material was utilized for banking the walls of the coffer-dam.

When an attempt was made to drain the coffer-dam, considerable leakage occurred, being especially marked adjacent to the old masonry pier, to which the coffer-dam was joined by pockets filled with clay and sealed against the old pier and it appeared to have been constructed on timber cribbing. On account of the perceptible vibration of the old pier by passing trains, the pumping was discontinued, as this operation tended to draw water through the old foundations, thus creating an element of danger. To avoid the possibility of danger, it was decided to use an air bell for completing the excavation and for depositing the concrete for the new pier. The inside dimensions of the coffer-dam were 17.5 ft. by 58.5 ft., the outside dimensions of the air bell being 12 ft. by 48 ft., with a height of 5 ft. This air bell was constructed adjacent to the work, and was hoisted above the coffer-dam by a derrick boat, with three air-shaft sections attached. The bell was sunk to the bottom inside the coffer-dam, with a space of 2 ft. 6 in. between the sides of the air bell and those of the coffer-dam. This space was filled with tremie-deposited concrete, the bell completely covered, and its top and sides were sealed, after which the water was pumped from the coffer-dam, and the concrete was deposited in the dry, to the water level.

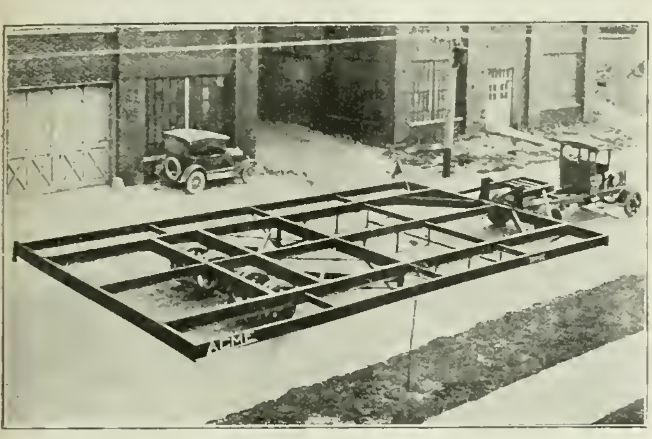
Air pressure was then applied to the bell and the water inside expelled. The underlying soil was removed, and as the rock was quite soft, excavation was continued 6 ft. into the sandstone. The concreting of the excavation, including the interior of the bell, was then performed under air pressure. The bell was of light construction, and the conditions under which it was used were distinct from those prevailing in the construction and use of ordinary pneumatic caissons. The absence of launching stresses or cutting-edge stresses, and the fact that the interior air pressure was resisted by the concrete enclosing the bell, conferred further advantages in this operation.

In the construction of the bell, 3 by 8-in., ship-lap pine sheathing was used, which was spiked to nine 6 by 10-in. pine cross-frames. The experience with the problems at this pier indicates that the air-bell method as adopted was the most economical.

The work was done in connection with the reconstruction of the B. & O. R. R. bridge, a full description of which is given in the April Proceedings of the American Society of Civil Engineers.

Moving a Village 11 Miles By Means of a Trailer

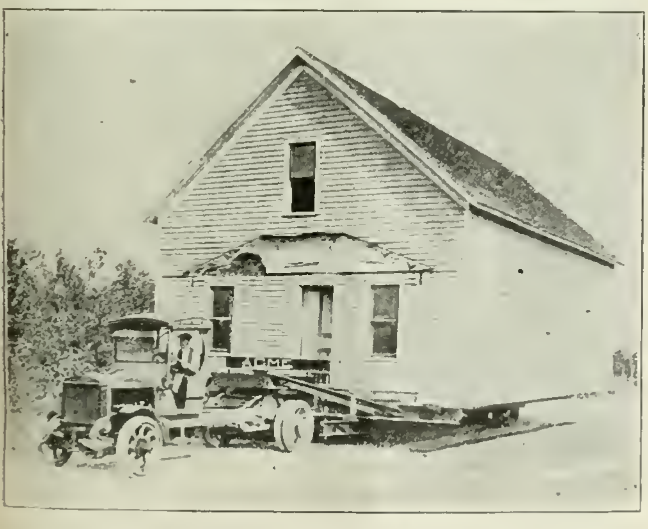
A trailer of unusual design is being used in moving practically an entire village to Cadillac, Mich., a distance 11 miles. The town of Jennings, 11 miles north and east of Cadillac, was founded about a quarter of a century ago by the Mitchell Bros. Lumber Co. A saw mill, chemical and flooring plant gave employment to approximately 500 men.


Trailer Built Especially for the House Moving Project.

Various plans were considered for the preservation of the industrial life of the little village, but all were discarded. Then came the idea of moving the mills, the families and the residences to Cadillac, 11 miles southwest. Many plans were considered and rejected as impractical before the motor truck and trailer plan was adopted.

The houses to be moved vary in size from 24x30 ft. to 24x40 ft. Many of them have hardwood floors, all are a story and a half high, well-built, comfortable and arranged for convenience. The weight of the houses varies from 15 to 35 tons. The windows are left in all of them. It is stated that the trailer functions so perfectly that not a window has been even cracked, except in passing through the City of Cadillac, when the limbs of shade trees along the street broke one or two when the first house was brought in.

The 11-mile trip is made in about 4 hours, which includes all necessary stops to wait for traffic to pass before entering upon a stretch of road too narrow to allow passing, though the actual running speed is from 5 to 8 miles per hour.


24x40 Ft. House, Weighing 35 Tons, En Route to Cadillac.

Loading and unloading and passing through the city requires a longer time than that, as it is often necessary to remove the electric light and telephone wires to allow the house to pass under.

At the time this article was written the rate of moving is about two houses every three days or four per week, although as the crew doing the work grows more accustomed to it it is thought a house a day will be brought over. There are from 75 to 100 of these residences to be moved.

The trailer proper is 24 ft. wide by 42 ft. long and has a framework of heavy structural steel beams. A channel and I-beam platform, raised 18 in. above the trailer frame and rigidly connected to it, transfers the load at the forward end of the trailer to a rocking fifth wheel mounted on the truck. This construction eliminates all twisting stresses from the trailer proper.

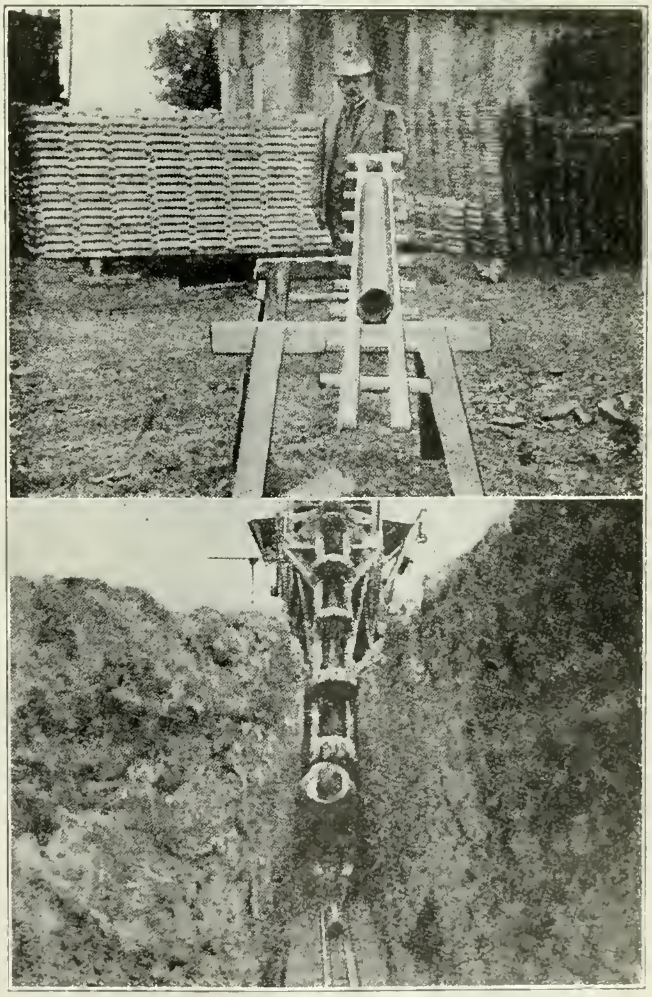
The trailer frame is supported at the rear by four steel truck wheels abreast, equipped with solid rubber tires. These steel wheels are placed under the trailer in such a position that approximately 75 per cent of the weight of the trailer and load is carried on them, thus making it possible to carry a very heavy load on the trailer without overloading the truck used for motive power.

The trailer is designed to safely carry a maximum uniformly distributed load of 35 tons, and the complete unit weighs approximately 5 tons.

The trailer was designed and built by the Acme Motor Truck Co., Cadillac, Mich.

Wooden Cradles Keep Drainage Tiles in Alinement

The business of laying drainage tile in swampy land is often an uncertain one, as eventually the tiles tend to "float," and so lose their alinement. The trench must sometimes be opened, as a result, and the tiles reset, joint to joint. In the work of reclaiming for horticultural purposes some 12,000 acres of waste land near Salt Lake City, however, this difficulty has been done away with by the use of a simple contrivance invented by the engineer in charge. (See Figs. 1 and 2.) This is a rack, or cradle, 10 ft. long, which consists of two longitudinal strips joined by 10 crosspieces. These racks are laid end to end on the bottom of the trench, like the familiar duckboards of war time, as the trenching machine progresses. The tiles are then laid between the strips. In this position they are firmly locked by the refilling of the trench.—Popular Mechanics.

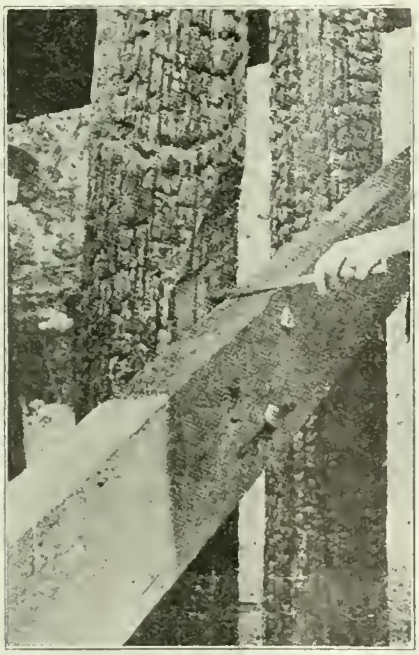

Figs. 1 and 2.

Creosoted Timber Shows Remarkable Resistance to Fire

Trestle Fire Burns Itself Out with Only Surface Damage to Main Members*

On the afternoon of May 27, 1921, trestle No. 83.2 of the Nashville, Chattanooga & St. Louis Ry., over Cypress Creek, on the Nashville division, a creosoted ballasted-deck structure, caught fire and burned for about two and a half hours. The heat was so intense that a bucket force of trackmen, attempting to use water brought from the creek, were unable to get near enough to the structure to do anything toward quenching the fire. The fire simply burned itself out, after sweeping over much of the surface of the timbers and charring them to a depth of ½ to ¾ in., but without weakening any of the principal timbers to an extent making necessary their renewal, except for the cross bracing on three bents, which were so badly burned that it was thought advisable to renew them, the expense of which amounted to only $75.

Traffic was resumed as soon as the fire had gone out, and inspection by the engineering department found that the structure was still quite safe for service, with the prospect that it would be good for traffic for many years to come. This trestle was built in 1918. This road began the use of structures of this kind in 1910, and now has 35,845 lin. ft. of them in service.



Side View of Piles With New Brace Timber.

In this particular trestle there was a deviation from standard plans in the detail of the galvanized iron protection for the top surface of some of the timbers. In addition to the galvanized sheet iron for pile head protection and on the ballast curbs, there was galvanized iron on that part of the creosoted caps extending beyond the stringers. This iron was transferred from the abandoned open deck untreated timber trestle on the old line and was placed on the new structure only because it was on hand. The use of galvanized iron on top of creosoted caps, in this class of construction, is contrary to the standard practice of the road.

Treated Timber Less Subject to Fire than Untreated.—The occurrence is remarkable in several respects, one being that while the fire spread quickly over the whole length of the trestle, starting in a decayed cedar fencepost from which it was communicated to the creosoted bulkhead at one end of the bridge, it confirms the opinion that creosoted timber in bridges is not liable to anything like the damage from fire that would result to untreated timber. Such fact is interesting in view of the opposition on the part of some engineers to the use of creosoted timber in trestles, out of consideration of which a number of roads are using reinforced concrete piles and concrete slabs at a cost of about double that of similar structures built of creosoted timbers.

Account of the Fire.—Various details of the fire and the resulting damage are supplied in reports to Chief Engineer Hunter McDonald by Assistant Bridge Engineer C. L. Wilson and Division Engineer J. M. Ryan. By courtesy of Mr. McDonald we are privileged to publish these details, taken from the reports, as follows:

The only parts of the structure which were not set on fire were the face of the batter pile of every bent on the south side, the faces of the stringers, the ballast curb, the ends of the decking and caps on that side; also, the faces of the different members of the structure in contact, such as the bearings of the decking upon the stringers, of the stringers upon the caps, of the caps upon the pile heads; and the faces of the stringers, which are separated one inch, were not affected by the fire. The reason the south face of the structure was not set on fire was because the wind kept the flames always in the other direction and away from that face.

The south face of the batter piles was not affected by the fire more than to draw a slight amount of creosote oil to the surface, which was quickly dried by the refracted heat. Further around, towards the east face, the surface was charred.

The faces of the stringers, above mentioned, which are separated 1 in., did not catch on fire, as there was no tendency for the flames to run into this small opening. This pocket is open only at the bottom, therefore, no draft was created to take the flames up between the stringers. Nevertheless, the heat was of sufficient intensity in this pocket to bring the creosote oil to the surface, which flowed to the bottom edges of the stringers where, coming in contact with the flames, it was burned. The tar ash remaining has, in some places, completely bridged this hole at the bottom.

It is, of course, understood that the top surface of the decking was not affected by the fire, this being covered by gravel ballast. However, the flames lapped over the ballast curb timber in several places and started the ends of the untreated ties to burning. With the exception of the above mentioned faces all timbers and piles were charred to a depth of from ½ to ¾ in.

The cross bracing on bents 2, 3 and 4 were burned to such an extent as to necessitate their renewal. No bracing was used on any of the other bents before the fire, but since it was thought the piles had become slightly weakened, as a matter of precaution bracing was placed on bents 5, 6 and 7, as shown in the illustration.

The fire was of such intensity that the leaves on trees about 60 ft. from the trestle and just inside the right-of-way line, on the south side, were scorched, notwithstanding the fact that the wind was keeping the flames always in the other direction. Leaves on the trees approximately 100 ft. from the trestle, on the north side and just inside the right-of-way line, were completely killed. The red cedar piles, still in place, of the dismantled trestle on the old line were set on fire. The smoke from the burning creosote oil was seen by farmers living ten miles from the trestle.

Examination of every possible means by which the fire could have started supports the opinion that live coals, falling from a passing engine, lodged between the cedar post of the woven wire fence and the creosoted timber bulkhead at the southwest corner of the trestle, were fanned into a flame by the high southwest wind, which was blowing at the time. The heat of this small fire was of sufficient intensity to draw the creosote oil out of the bulkhead timber, which in turn ignited very readily. Once started, the flames passed from one member to the other and spread rapidly over the entire structure, being accelerated by the high wind.

After the fire had gotten a good start the heat was so intense that the bucket gang, which was organized, could not get within 50 feet of the structure. It was only after most of the fire had died out that the men were able to approach close enough to throw the water with any success. It was thrown on the bracing, which was still burning slightly, and, also, to the upper surface of the decking with the expectation of it running through the small spaces between the timbers and distributing over the stringers and caps.

Fire Smothered Itself.—From the foregoing fact and the appearance of the charred portion of the timbers, there is no doubt but that the fire smothered itself. As the oil burned out the residue ash (tar ash) was left in combination with the wood ash and formed a coating which prevented the admission of oxygen to the unburned portion of the wood and the oil contained therein.

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*From the Railway Review.

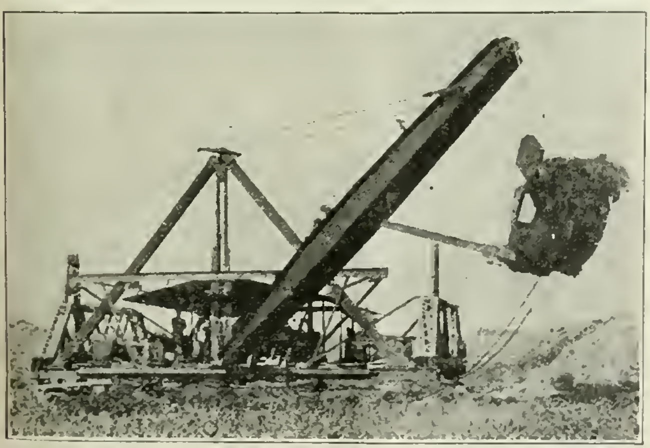
The terrific heat was caused by the creosote oil burning, as it gradually oozed out of the surface cells of the timber, accentuated by the blast action of the high wind. A small test fire was made with some of the chips cut from the face of the charred piles in fitting additional cross bracing on the damaged bents. It was found that the oil oozed out very readily, even in these chips. The timber and the oil burned until a coating was formed on the surface by the slight wood char and the ash from the tar in the oil, and then went out of its own accord. These chips, which were thin, and the present timber in the structure, show every indication of a sufficient amount of oil still remaining in the wood to preserve it from decay. The illustration shows where the face of the pile was cut about ¼ in. into good timber to accommodate the additional cross bracing. The chips from such cuts were used in making the test fire. Plenty of oil is still in evidence in the piles at these cuts.

The heat to which the remaining timber was subjected does not seem to have affected its strength to any appreciable degree, if at all. The length of time the trestle was on fire was about two and a half hours. Making an allowance of 50 per cent of this to cover the time required in gaining its maximum intensity and to die out, will give only about one and three-quarter hours that the entire trestle was subjected to the hottest fire. The fire was quick and the heat had very little chance to penetrate deeply into the timber. Shortly after the fire was completely out some of the charred timber was scraped and it was found that the sound timber beneath was not even warm.

Traffic was resumed as soon as the fire was extinguished and, with the exception of the new bracing, above mentioned, no other repairs have been found necessary. This fire shows rather conclusively that creosoted timber structures, properly designed and cared for, are not, as is supposed by some, a great fire hazard. Had this trestle been built of untreated timber it would have been completely destroyed.

New 1½ Yd. Land Dredge

A new 1½ yd. land dredge having a number of improvements has been brought out by the Bay City Dredge Works, Bay City, Mich. It is stated that the new machine can be operated at only a slightly higher cost than that for the operation of a 1-yd. dredge. No extra men for crew are required, the only additional expense being the greater amount of fuel burned by the engine. The standard engine equipment is the Charter's heavy duty 2-cylinder dredge engine. Among the mechanical improvements of this machine the more important are the following: Plate steel boom; type Z dipper; all steel castings; band type clutches; heavy geared crowding device, and double cable on the boom guy. The machine is similar to the Bay City 1 yd. dredge, but is, of course, much larger and more heavily constructed throughout. The total shipping weight is slightly over 100,000 lbs. Two of these 1½ yd. machines have been shipped into Minnesota in the past two months and the company is building a third, which also will go to that state.



New 1½-Yd. Bay City Land Dredge.

Urban Electric Railway Tracks

Principles of Construction Outlined in Paper Presented at City Paving Conference, Philadelphia

By E. J. McILRATH,

Engineer of Way, Philadelphia Rapid Transit Co.

The principal purpose of the street railway track structure is to transmit the loads of the cars or of the vehicles running over the track, running through the rail and the ties to the soil underneath, in such a way that the unit load on the soil is well within its bearing power, even when it contains considerable moisture.

In steam railway practice, the rail is chosen with such stiffness that, with the given depth of ballast under the ties, the load is transmitted to the sub-grade in such a blanket fashion that the sub-grade is able to carry the load without yielding. Because of the intensity of the wheel loads, some flexibility is desirable in the track structure.

In street railway practice, the same intensity of load is not found. A much stiffer rail is usually used and a monolithic paving must be maintained. The sub-grade conditions are not so perfect because other public utilities run ditches under the track; broken water mains will develop; breaks will be produced in the paving and water runs into the subgade. Vertical movement of the rail cannot be permitted, but so long as the structure is able to distribute the loads to give a light enough pressure per square foot of area of the sub-soil, the simplest and cheapest type of structure should be sufficient. The excessive stiffness or rigidity of the structure that makes it act as an anvil under the hammer blows coming from cars and vehicles rolling or bumping over the inequalities of the track or paving is likely to defeat its purpose and produce a structure of shorter life than would be obtained with a less rigid, cheaper construction, and may also be much more expensive to remove when rebuilding becomes necessary.

It is common practice, and very good practice, in building lower buildings, even up to 6 stories and, in a few cases, above 6 stories, to have no support at all but the natural soil at the depth of the basement. Reasonable width footings are provided so that the bearing power of the soil shall be well above the load carried on it. There is no question as to the desirability of subjecting soil to that kind of loading.

Distribution of Load in Paving Practice.—In street paving of the modern type, a similar condition prevails. A concrete slab of sufficient thickness is placed over the soil to distribute the wheel loads over an area that is sufficiently wide to give an intensity of loading well within the safe carrying power of the soil. Water-bound macadam roads serve the same purpose, that of shedding most of the water, preventing its entering the soil underneath, and distributing the load through the macadam structure to a wide enough area of the sub-soil so that the sub-soil is able to hold up under the load. Water-bound macadam and asphaltic macadam are similar in type and purpose for road service to the ballast of street railway or steam railway construction. So long as the street railway structure is able to blanket the soil underneath, to give an intensity of loading comparable to the intensity of loading under the street paving outside the track, even when a reasonable amount of moisture is present, the track paving will be maintained in good condition and the track will be serving its purpose well.

There are two general classes into which street railway structures might be divided: First, track supported on ballast or on natural soil; second, street railway tracks supported by a solid concrete slab. In Philadelphia and in several eastern cities the first class is most common.

Track Practice in Philadelphia.—The practice in Philadelphia is to use a 9-in. 141-lb. girder rail, laid on 5 in. x9 in. x 8 ft. ties, spaced 22 in. on centers. The rail has a stiffness more than twice that of the 7-in. 122-lb. A. E. R. E. A. section and, therefore, spreads the load over a large number of ties and, in fact, is so stiff a girder that, with a load of 30,000 lbs. placed in the middle of a 72-in. span, the deflection would be less than 0.05 in. Each tie has a bearing area on the soil of 6 sq. ft. The cars loaded weigh approximately 26 tons each truck carrying 13 tons and having a wheel base of approximately 5 ft. Assuming only 5 ties of 22 in. spacing are carrying a load of one truck, there would be 30 sq. ft. supporting 13 tons. A fairly sandy soil, such as exists in Philadelphia, should carry 4 to 6 tons per square foot, or, in other words, a safe load for a structure carrying 13 tons would be approximately 150 tons. Is it not then clear that a very safe margin of loading exists, and that any more expensive structure to install, to maintain, or to remove, that would still further blanket the load over a wider area of soil, would represent a waste of money? The rigidity of the rail, the large size and close spacing of the ties sufficiently distributes the load, while the anvil effect that would exist if the ties were supported on a heavy block of concrete is avoided. The extra rigid slab tends to permit a piano string type of vibration in the rail.

Drainage or Ballasting for Subsoil.—There are soils, however, and we have some of them here in Philadelphia where the moisture content, due to their readiness to absorb and hold moisture, is usually too high, and the bearing power of the soil in certain seasons of the year may be as low as 1 ton per square foot. The drainage of this sub-soil is usually cared for as well by the city sewers as if additional drainage were supplied by the railway company. The presence of the sewer keeps the water level in the soil, at least as low as the sewer, and the water coming in through the paving to the sub-soil is not easily collected to a drain when the soil is a soft clayey type.

A much better method of preventing trouble is to have a layer of porous material between the track structure and the soil, in order to permit the water that penetrates to flow along and distribute itself in this layer of porous material. Then the water does not localize, nor does the track structure have the opportunity to puddle the soft soil by its vertical movement at points where slight settlement or springiness has developed. The water is contained in a non-puddling material and water will collect on top of such soil.

When a concrete slab under the track is directly in contact with such a soft soil, the hydraulic pressure developed at the points where slight settlement of a ditch has occurred carries some of the soil from under the slab to the surface of the street, making a greater void, causing a greater settlement and a greater sluicing action. In fact, considerable difficulty is noted in maintaining concrete supported track over soft clayey soils without a layer of porous material between the concrete slab and the clay. This material may be hard clean cinders, a fine gravel, coarse sand, or some material which thoroughly blankets the soil; but not a coarse crushed rock or equivalent.

The same result is obtained if a sufficiently deep layer of porous, but not open ballast, is placed between the bottom of the ties and the top of the clay. The depth should be sufficient to give the required distribution of load that will be within the bearing power of the soil. Less likelihood will exist of hydraulic pressure developing to sluice out the clay, and the deadening of the piano-string type of vibration of the rail will assist in prolonging the life of the top paving and, therefore, the entrance of water to the soil will be longer delayed.

When a crushed rock ballast of, say 1 in. or 1½ in. size is used in track construction, it does not serve as well as a much finer ballast would. The crushed rock large size has a small proportionate area in contact with either the soil or the tie. The tendency then is for the soft soil to squeeze up into the voids of the rock, permitting settlement of the track. On the under surface of the tie, the rock can only support the tie with a very small percentage of contact area. The rock cuts into the tie and permits track settlement. If, however, a porous material is used which blankets the soil and gives full surface bearing to the tie, this squeezing of the soil and cutting of the tie does not occur and the track is much more likely to stay solid and at its proper grade. If such squeezing up of the soil does not exist, then the soil in itself has such a good bearing power that it should be able to support the tie without crushed rock ballast; the addition of the ballast is a waste of money. If the tie is not being cut by coarse ballast, it must be a very expensive hard wood tie, or the loads are light for the size of the tie used. Here again an economy would be possible by using a softer wood tie with blanket area of the ballast, and a longer life would still be given.

In steam railway practice, coarse ballast is more easily defended, because the sub-soil drainage is good and because a slight settlement of the track is not a defect, yet we understand that at least one of the large railroads is beginning to use a much finer grade of crushed rock to avoid the difficulties above noted.

Paving for Street Railway Track.—In the construction of new paving on the street, it is important to have the work thoroughly and carefully done, so as to have not only a very uniform track support, due to uniform tamping of the track or uniform packing of the sub-grade, but also in order that the soil under the track and the soil under the rest of the street be uniformly damp at the time the concrete slab is placed for the paving base. It is highly desirable to avoid cold joints running lengthwise in the street wherever possible.

It frequently happens, however, that the track strip is concreted before the area between the track and the curb and after a soaking rain the contractor will proceed with the work when the top 8 or 10 in. of the sub-soil is thoroughly wet and not firm enough to permit the placing of the concrete slab. The result is, of course, that the sub-soil under the track has a tendency to shrink and the sub-soil under the rest of the street will shrink ½ in. or more in depth. This naturally will create a break along the joint next to the track strip. Sometimes this develops rapidly into a crack on top of the street, water penetrates to a sufficient extent to weaken the track and the railway company is blamed for faulty construction when, in reality, the blame lies with the city or with its contractor.

In considering the type of paving for a track, there is little choice in busy streets. Granite block is much preferable under heavy service. With iron tired travel, cement grout filler is preferable. Brick may be quite successful in those districts where an exceptionally good repressed vitrified brick is available or where the iron tired travel is a minimum; monolithic concrete will have a longer life with a very stiff track structure under light travel; and sheet asphalt and bitulithic paving with granite running courses on each side of each rail can make a very desirable paving for streets carrying proportionate traffic. With a light rail or light structure, where, after a period of years, some vertical movement of the rail is likely, or where the side stiffness of the rail is not adequate, cement grout filler for granite block is highly desirable. Where the rail is heavy, stiff and well supported, an asphalt filler, or much better, a mixture of a good grade of bitumen filler and sand will serve very well indeed and is much easier to repair, or to remove for track repairs. It does not, however, provide a better water shed than the cement grout filler.

The cushion under block paving should be laid damp, of a cement sand mixture that will set up hard, to give monolithic support to the monolithic top paving. The use of sand alone is not desirable. Wood block is not a good paving material used around street railway tracks. It is almost inevitable that water will get under the wood block near the rail and will then penetrate along the fibers of the wood, causing the wood block to swell and heave.

Why Pavement Breaks Occur Around Special Work.—Paving breaks down much more rapidly around special work and at street intersections than along the straight track. This is due, in many cases, to the fact that the hammer blow from the cars passing over flangeway intersections is given to a structure made rigid by being supported on a solid block of concrete, the resultant vibration producing seams into which the water penetrates, but the most serious cause of breakdown of this paving is the contour of the street. The municipal authorities like to have street intersections as flat as possible and the water invariably lodges around the railway tracks at the street intersection and penetrates to the sub-soil at the weakest point of street railway tracks, because of the vibration that must exist at flangeway intersections. If the streets were so graded that the water running along the straight track would be carried off before it reached the street intersections a longer life would be given to the paving.

The hammer blow does not only come from street car passings, but heavy vehicles soon produce a hammer blow when crossing the rails. This is much more severe than that produced by the cars, unless the paving is well laid, is of a good type, and is carefully maintained in true surface for these vehicles. Again, it is not infrequent to have one or more manholes for sewers or water valves, or for telephone companies, light companies, gas companies, or steam heat distributors placed right in the special work layout. The resultant track construction must be a makeshift which inadequately supports the track, although the track at these locations needs the most perfect support.

At street intersections faulty paving is much more noticeable to the public and causes much more inconvenience than if the faulty paving were along the straight tracks. It is highly desirable then that the municipal authorities co-operate with the railway company to remove the present handicap to good construction at intersections. The street railway company alone cannot prevent these intersections from being the weakest points and the points of greatest nuisance. The cost to the city and to utility companies may be greater than under present construction, but the convenience to the traveling public and the appearance of the city will well warrant the additional expenditure by all concerned.

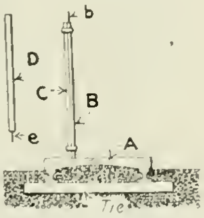
New Type of Special Work at Philadelphia.—In Philadelphia we are now introducing a new type of special work made of cast weldable nickel chrome steel with a flange bearing throughout. This should be much more readily maintained as smooth running special work without the hammering that exists where full flange bearing is not given and where the material is not weldable so it can be maintained in nearly its original condition. This, together with a type of foundation which deadens the vibration, yet distributes, without puddling, what moisture penetrates, should improve the life of the structure and of the paving around the structure. The city, however, must provide better drainage conditions and should insist on the placing of manholes away from track crossings.

I wish to emphasize the desirability of complete sympathy and co-operation between the railway company and the municipal authorities, in order that a type of construction may be approved and used which entails minimum cost in construction and in removal, which provides an appropriate condition during the life of the structure and which is designed to be suited to the particular conditions that are to be met.

No one type of construction is satisfactory for all locations, no one method of treatment is always the best, and the introduction of the most expensive type sometimes gives the shortest life and the greatest maintenance cost. The neglect of one or more essential details in a given type of structure may cause it to fail, while a proper recognition of the value of details might make that same type of construction most appropriate to the conditions. When developing specifications then, it is not desirable to insist on a specification merely because a large number of prominent companies or municipalities are using that specification. Standard specifications can be utilized as standards in various localities and in many cities, but the right standards for a given set of conditions must be chosen, since the adoption of the wrong standard may prove quite unfortunate.

Device for Measuring Height of Overhead Obstructions to Street Railways

A simple device for measuring the distances from the rail level to the trolley wire, wire trough and the lowest part of a bridge structure, is shown in the accompanying illustration, reproduced from the Electric Railway Journal. The apparatus is described by Joseph E. Rapuano, of the Maintenance of Way Department of the Connecticut Co., as follows, in the above mentioned journal:



The apparatus consists of a dry wood board, A, made to fit the two rail heads and the crown of the pavement, and a wooden rod, B-C, graduated to read up to 14 ft. or more. The auxiliary wooden rod D is added to B by inserting the cylindrical end e in a recess provided in the cylindrical end b of the main rod, thus enabling one to measure beyond the reach of the main rod.

Texas Engineers Meet Oct. 20.—The fall meeting of the Texas Section American Society of Civil Engineers is to be held in San Antonio, Oct. 20 and 21. E. N. Noyes, 1107 Dallas County Bank Bldg., Dallas, is Secretary.

Bridge Inspection and Maintenance on Interurban Railway

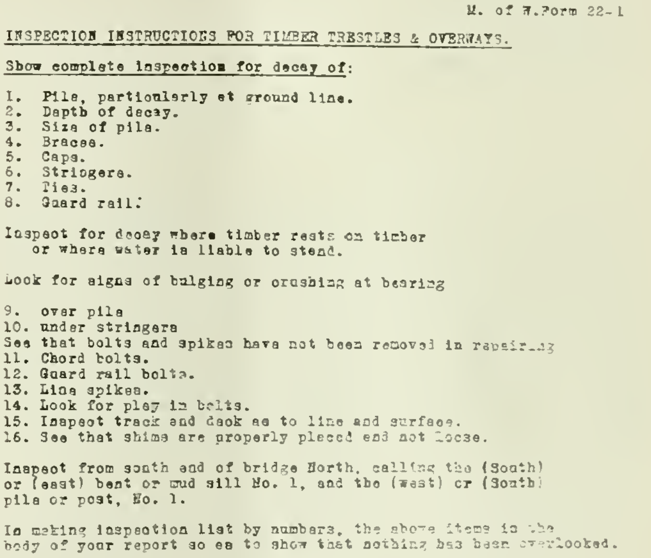
How the Chicago, North Shore & Milwaukee R. R. Systematically Suspects and Maintains Bridges on Its High Speed Line Described in Electric Traction

By J. H. HYATT,

Engineer Maintenance of Way.

The culverts and bridges on the C. N. S. & M. were constructed in general in three distinct periods in the property's development, resulting in each case in the necessity of a different type of inspection. A brief historical summary of this development will make this necessity clear.

The original property, known as the Cliff City Electric Street Ry. Co., was projected from the city of Waukegan south to Evanston, Ill. This property was constructed in the early development of the electric railway, and on account of the experimental nature of the venture the costs of construction were kept at a minimum; yet, on account of the character of the territory and the keen competition that the road would receive, it was early recognized that the property must be so constructed as to give rapid transit. This part of the road paralleled the main line of the Chicago & Northwestern Ry. Co., and it was possible to get track materials delivered at very frequent intervals along the route. These conditions made it uneconomical to utilize a large amount of timber in the construction of bridges and culverts, so that from the very first practically all of the construction was of a permanent type, but in order to hold the expense to a minimum these structures were made as short as possible and of as light a loading requirement as was consistent with the rolling stock to be carried.



M. of W. Form 22-1

INSPECTION INSTRUCTIONS FOR TIMBER TRESTLES & OVERWAYS.

Show complete inspection for decay of:

1. Pile, particularly at ground line.
2. Depth of decay.
3. Size of pile.
4. Braces.
5. Caps.
6. Stringers.
7. Ties.
8. Guard rail.

Inspect for decay where timber rests on timber
or where water is liable to stand.

Look for signs of bulging or crushing at bearing

9. over pile
10. under stringers

See that bolts and spikes have not been removed in repairing

11. Chord bolts.
12. Guard rail bolts.
13. Line spikes.
14. Look for play in bolts.
15. Inspect track and deck as to line and surface.
16. See that shims are properly placed and not loose.

Inspect from south end of bridge North, calling the (South)
or (east) bent or mud sill No. 1, and the (west) or (South)
pile or post, No. 1.

In making inspection list by numbers, the above items in the
body of your report so as to show that nothing has been overlooked.

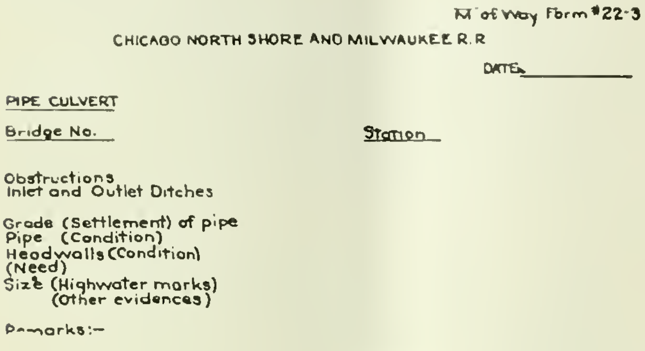
Form for Reporting General Inspection of Bridges by Supervisor of Bridge.

When the road was reorganized into the Chicago & Milwaukee Electric R. R. Co., and the line projected to Milwaukee, there was a determination on the part of the promoters to make this one of the best of interurban railroads, and with this point in view the design of all the structures was for an increased loading, and ample width for two additional tracks. This program was continued almost up to the time in which the road became involved in financial difficulties. That part of the road, however, which was constructed in the latter part of 1907 and completed by the receivers, was characterized entirely by timber trestles and structures.

Hence, with the development of the property, it has been necessary to enlarge and strengthen permanent structures built by the Bluff City Ry., while comparatively a small amount of maintenance and no strengthening or enlargement has been required on structures built by the Chicago & Milwaukee Electric R. R. At the same time, the temporary structures completed by the receiver have required the usual constant inspection and renewal of timber bridges

During the period while this property has been developing, it was felt proper to renew only such structures as impaired the safety of the service, and such as were comparatively expensive to maintain. Some of the timber structures were extremely temporary in character, necessitating a large amount of repairs almost from the very first.

When the writer became engineer maintenance of way, for the receiver, he found on the property several very high and long timber bridges, the maintenance of which was very burdensome. These bridges, in fact, were in such condition that it was practically necessary to make almost daily inspection of them. Fortunately, at this time there also existed a condition that required the widening and ditching of a great many of the larger cuts in the vicinity of these structures in order to keep the roadbed in proper riding condition, and it was possible to persuade the receiver to fill these more temporary structures, thus eliminating by one improvement two very serious roadway conditions. In planning the work of elimination of these structures and the ditching of the right of way, it was found advisable to purchase a ditcher, and this machine, while being primarily a roadway tool, has played a very important part on our property in the maintenance of bridges.


M of Way Form #22-3

CHICAGO NORTH SHORE AND MILWAUKEE R.R

DATE____

PIPE CULVERT

Bridge No.____ Station____

Obstructions
Inlet and Outlet Ditches

Grade (Settlement) of pipe
Pipe (Condition)
Headwalls (Condition)
(Need)
Size (Highwater marks)
(Other evidences)

Remarks:—

Special Form for Reporting Inspection of Culverts.

Daily Inspection.—The other strictly temporary trestles were replaced, as soon as it was possible to do so, by permanent structures of steel and concrete, but during all the period in which these structures were maintained the safety of the traveling public has been safeguarded by daily inspection which corresponds practically to the track walker. This inspection, however, was made by an intelligent member of the bridge and building organization who was sufficiently familiar with bridges to recognize the beginning of any unsafe condition.

While all the bridges on this property have now been either replaced with permanent construction or so strengthened as to preclude any necessity for daily inspection, yet this early condition undoubtedly led to the present method of bridge inspection, which consists essentially in a current inspection and a general inspection.

Our current inspections may be made by any intelligent member of the bridge and building organization, but as a rule one particular employe is designated to do this work. His report is made out in duplicate, showing the condition that he finds each bridge in, and enumerating the work required to maintain the structure in good condition, and the work which must be done to keep the structure safe. These inspectors are instructed that whenever there is any work that they consider must be done to keep the structure safe, that this information will be telephoned to the general bridge foreman immediately upon discovery of the same, and proceed immediately with the execution of this part of the work. These current bridge inspections are summarized by the general bridge foreman in a report that he forwards to the engineer maintenance of way on the fifth of each month, on M. of W. form No. 23, illustrated herewith, which report states what action has been taken on recommendations made by the bridge inspector.

General Inspections.—In addition to these current inspections, general inspections are made once or twice a year, using M. of W. form No. 22. These general inspections are made by the supervisor of bridges and an assistant engineer, who go over the structures carefully and make such tests as in their judgment are necessary to determine the soundness of the piles and timbers in timber structures. In doing this, we utilize a special hammer made particularly for this purpose which enables us to easily determine the depth of decay in piles and timbers and to sound the timbers for hidden defects.

To aid the inspectors in the inspection of these bridges, the principal items of defects are enumerated on an instruction sheet and their inspection is to follow the items in the order enumerated, so that when these reports are turned in at the engineer's office they become immediately intelligible by anyone. Thus, for example, while the depth of decay on piles is asked for, the size of the piles is also asked for, the two elements being considered together. The instructions issued to inspectors are as follows:

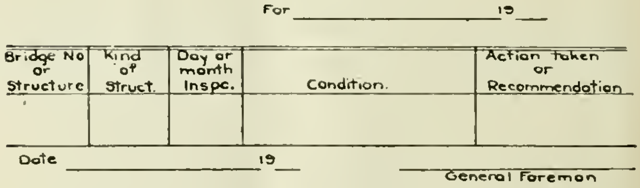
In bridge inspection there should be a clear distinction made between current inspection (reported on form M. W. 21) and general inspection (reported on form M. W. 22). The purpose of the current inspection is to keep the structure in safe condition, to discover any defects and to report the same promptly, so that repairs can be made before the safety of the structure is affected. It is important that a simple record should be made while at the structure and that the engineer maintenance of way be kept advised of all such inspections whether made by a bridge mechanic, gang foreman, inspector, carpenter or others.

It shall be the duty of the general bridge foreman to see that these inspections are made by a competent man at frequnet intervals. The general bridge foreman shall receive a copy of the report of all such inspections and shall make a report of action taken on all reports of the previous month on the 5th of each month, forwarding the same on form M. W. No. 23 to the engineer maintenance of way.

The purpose of the general inspection, frequently called the annual inspection, is not only to check the maintenance work of the division organization, but to make a careful investigation of important bridges and structures on the entire road and, further to ascertain and determine what extensive repair work or renewal work should be done in the following working season.

Inspection of Pipe Culverts.—In the case of inspection of pipe culverts, a report on waterways is also requested. The pipe is inspected for condition and for displacement by settlement of grade or giving away of foundations. The condition of the headwall is investigated, and if there is no headwall, the question of need, which changes from year to year due to the track program.

High Water Marks.—In all inspections of small bridges and culverts, particular attention is given to evidence of high water, as frequently the railroad is met with claims of inadequate capacity and it is found frequently that the backing up of these streams is often caused by obstructions and changes over which the railroad company has no control, and in our annual inspection all these things are carefully noted so that the railroad company will be in possession of all the facts, and in the case of temporary structures, that we may have the best facts upon which to base the design of permanent structures.


M of Way Form #23

CHICAGO NORTH SHORE AND MILWAUKEE RAILROAD

SUMMARY CURRENT BRIDGE INSPECTION REPORT

For________________19___

Bridge No or Structure	Kind of Struct.	Day of month Inspc.	Condition.	Action taken or Recommendation

Date ____________19___ ________________ General Foreman

General Bridge Foreman's Report of Bridge Inspection.

Copious notes are kept in addition to the information asked for on the forms and compared with those of previous years, making note as to whether or not authorized work has been performed. A joint report is then made, which, with the recommendations for reconstructions or renewals to be done the following season, is submitted to the engineer maintenance of way for his approval.

Permanent Bridges.—In the inspection of permanent bridges, particular care is given to determine any hidden defects, and if there is any evidence that will lead to a suspicion of failure of any part of the structure, very accurate methods of tests are involved to determine the facts. For instance, a long retaining wall built by the Bluff City Ry. gave a suspicion that the same was yielding to an overturning pressure. Monuments were immediately established, determining a fixed transit line and the movements of this wall were carefully watched by frequent accurate measurements by the engineers. It is significant of the confidence placed by the management in this system of inspections that this retaining wall, which had a bad appearance and a failure of which would have been very disastrous, was kept in service for six years after it was under suspicion and was being watched by this method, and that when the engineers decided that the amount of movement was too great to be longer disregarded, within four days arrangements were completed for removing an adjacent road (which required action by the city council) and a steam shovel was cut in and the wall was being filled with an earth embankment against its face.

Special Problems.—Deflection on lighter bridges has been carefully kept and all these records have been available for the use of the bridge engineers in making their studies for the strengthening of these structures as the heavier traffic demanded. Painting programs are all carefully mapped out on this annual inspection and as each bridge is stencilled at the date of its last painting, the engineers are enabled to observe at first hand the behavior of various bridges at different locations in this respect.

The comparison of annual inspections with those of previous years has enabled the engineers to frequently correct defects in design in time to prevent the premature renewals that otherwise would be required. For instance, a highway bridge over the tracks that had been built with a wooden deck and which had appeared to be the most economical type was suddenly found to be wearing very rapidly. Upon investigation, it was found that the traffic over this bridge had enormously increased and it would probably be impossible to maintain this type of floor under this traffic. Accordingly this floor was immediately protected by covering it with a pavement of penetration tar macadam and thus eliminated what would otherwise be a large increase in the maintenance cost of this bridge.

In another instance, a crack in a wing wall of an abutment adjacent to the main line of a steam road was observed to be considerably larger than recorded the previous year. Workmen were immediately put to work breaking out the concrete along this crack and it was discovered that there was a bad defect in the interior of the wall running to the back, which was allowing water to enter, and the winter freezing was breaking up the wall. Immediate action in cutting out all poor concrete and reinforcing the wing wall with new concrete bonded to the old wall resulted in the stopping of disintegration that would soon have destroyed the wing wall.

Deterioration of Stored Cement.—Deterioration of cement stored in bulk is less than in bags, owing to the smaller area exposed, states the United States Bureau of Mines, as the result of an investigation to determine the cause of deterioration of portland cement during storage and transportation. Hydration takes place only at the exposed surface, and the bulk of the cement is unaffected. Cement transported in bulk must be shipped in a tight, closed car, and must be protected from moisture during loading, shipping and unloading, preferably it should be used immediately after unloading at the point of destination. This practice is now followed by several manufacturers and where conditions are suitable it is becoming more common as its advantages are seen. Shipping in bulk effects a saving by eliminating the use of bags—which is an important item in the cost of cement—and it should also permit a saving in freight rates. Details of a study of the storage and transportation of portland cement, with a bibliography on the subject, are given in Serial 2377, obtainable from the Bureau of Mines, Washington, D. C.

Engineering in Railroad Transportation

Application of Engineering Methods in Transportation Problems Described in Paper Presented Before Western Society of Engineers

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Railroad transportation in its general sense embraces the whole broad field of railroad activity; the construction of roadbed, bridges, tracks, buildings, locomotives and cars; the maintenance of way and of equipment; the solicitation of traffic; the making of rates; the operation of trains, stations, terminals, warehouses and docks; the accounting of the revenues and disbursements; and last but by no means least the financing necessary to carry on such vast undertakings. The essential part which engineering has played in the construction of the railroad system of our country and in the development of the railroad transportation industry is historical, and will not be dwelt upon here.

In its more restricted or special meaning railroad transportation applies to that part of the railroad industry having to do with the movement of freight and passengers, the supply and distribution of motive power and cars, the making and maintenance of train schedules, the operation of freight stations, docks and floating equipment. In this sense transportation is synonymous with operation as opposed to construction and maintenance. It takes the railroad machine and by the turning of the wheels produces the finished products of the railroad industry—passenger miles and ton miles. It is to this special or technical meaning of transportation that the discussion will be largely confined.

The Criterion of an Engineer.—Let us consider what is the test or criterion of an engineer. Is it the degree of civil or mechanical or electrical or mining engineer conferred by an institution of learning? Without any thought of disparagement of the value of such degree and with full recognition and belief in the advantages of the training of technical men in our colleges and universities, the answer is, No. What then is the measure of an engineer? The national engineering societies require as qualifications of membership from six to ten years' actual practice and some four or more years in responsible charge of work—graduation from a school of engineering of recognized standing being equal to two years of actual practice—and, moreover, the ability to design engineering works. Experience, then, is the requisite of the engineer; and knowledge and ability gained through this experience, as evidenced by having been in actual charge of work, of having directed such work and of being competent in engineering design, are the things which measure the engineer.

The officers of our railroads, the trainmasters, superintendents, general superintendents, superintendents of transportation, general managers, and others, whatever their titles may be, who have direct charge of transportation, through their knowledge and ability gained in the school of experience, as evidenced by the organizations, the operations, the work under their direction, have qualified as engineers, transportation engineers, just as truly as have our engineers of construction, mechanical engineers and maintenance engineers qualified in their respective branches of engineering. And our usefulness as transportation engineers is measured by the skill with which we carry through our undertakings, by our ability to do well with one dollar that which can easily be done with two after a fashion, by our capability to truly comprehend and bring about the proper balance between locomotive maintenance, locomotive operation, and other transportation expenses.

Relation of Engineering to Transportation Problems.—Moreover, the methods of engineering are generally applicable in dealing with transportation problems. They consist, briefly, of surveys, observations or other means of collecting data, the marshalling of this data by means of drawings, tabulations or other convenient form, the study and analysis of the information thus prepared, the designing of structures or works or the planning of methods of procedure, and the actual construction in accordance with the designs or the execution of the work according to the plans.

In some of the problems of engineering the conditions are to a large degree fixed or constant and can be met with designs or plans of work which are to a certain degree permanent. In others the conditions are gradually changing and have to be met by changes in design. The demands upon the steel rail imposed by increasing wheel loads is a well-known example of the latter.

In no branch of engineering, though, is there such continual changing of the conditions as in railroad transportation. Not only is it subected to varying physical conditions, as by the seasonal changes of temperature and other weather conditions by which also the maintenance of roadbed and tracks are affected but the flow of traffic is subected to the same seasonal changes and in addition there are many other influences constantly being brought to play upon it. Among these may be mentioned the varying business and industrial conditions; the interruption or restriction of traffic on certain routes by floods, washouts, storms, congested facilities and other causes, resulting in diversions to other routes and thus bringing about heavy increases in the volume of the business to be handled; strikes in the basic industries of coal mining and steel production, making necessary heavy movements in unusual channels or sharp curtailment of the flow of traffic; the discovery and development of new sources of raw material, as of oil fields; and lastly competition, especially in periods of thin business.

This inherent characteristic of transportation, variability, places upon the transportation engineer the task not only of thorough study and analysis of the problems arising from the more constant conditions but also of continually meeting in an effectual and economical way new situations which, although they present themselves almost daily and without warning, are persistently different from their predecessors. A former operating vice-president wrote a few lines in his own handwriting to a newly appointed superintendent of transportation. He said in part: "The successful transportation officer handles his business hot off the bat. Your experience as superintendent will enable you to make decisions quickly." In these terse sentences are fittingly implied the emergency phases of transportation work and the training which qualifies the transportation engineer to successfully meet them.

Train Operation and Traffic Requirements.—In some classes of service the requirements of the traffic fix to a large degree the general features of the schedule, the size of the trains and the character of the equipment. This is particularly the case in passenger service and the opportunities for economics are not so great as in other branches of service. But even here continued and careful analysis will bear fruit. On a division where there are a number of local passenger runs it may be found feasible by changing the lay-up points of engines and cars or by coupling up runs to reduce the number of locomotives and cars required, and even to reduce the crew expense. And as passenger travel varies with the seasons and from other causes, it will frequently be found that cars can be taken off during light periods and so save locomotive fuel and repairs to equipment and insure greater reliability in the observance of the schedules. Where a passenger train has a fast schedule, particularly if there are a number of stops, the elimination of one car from the train will make a considerable saving in the amount of fuel consumed in making the runs. The cutting off from a 6-car train of one heavy car will easily save a ton of fuel on a 100-mile run over the average profile.

An important feature of transportation is the adaptation of train operation to the requirements of the traffic. The problems to be met vary from the simple one of a slow moving traffic, as of coal or ore on some engine district reaching into the mine fields, where the business can best be handled in slow freight trains, with perhaps one or two local passenger trains per day, to the busy multiple track trunk line with a heavy and diversified traffic, requiring two or three classes of passenger trains with varying schedules, express and mail runs, two or more fast freight trains, a large volume of slow freight to be moved in tonnage trains, and the local and pickup trains which handle the way freight, do the station switching and move cars to and from local points.

Each case between and including these extremes offers a different problem. A simple one is that of an engine district having a mixed freight traffic requiring some two or three through freight trains, a local freight train, and two local passenger trains per day in each direction. It will probably be found that the best freight service can be given by running at least two freight trains daily on definite schedules, suitably spaced throughout the 24 hours, and handling any additional business in extras, run daily or every other day as required. The freight trains may be heavily loaded and the schedules slow but if they are maintained with regularity the service will be reliable and satisfactory from a traffic standpoint as well as economical and efficient in the use of locomotives and cars. Branch line trains of this kind should be scheduled to arrive at the junctions so that cars of important freight can be switched out and forwarded without excessive delay in fast freights on the main line, thus affording continuous movement to destination.

With a more complex traffic situation a more elaborate arrangement of train service must be provided. Through passenger trains will be required, one or more fast freight trains, such slow freights as may be needed and perhaps a pickup or local switch run if the way work is heavy. The important thing is to plan the train service so as to be attractive to travelers and shippers. The railroad is often compared to the manufacturing plant but there is this vital difference—the manufacturer, as a rule, turns out the finished product before it is sold, the railroad must sell its product—passenger miles or ton miles—before it can even start to produce them. The manufacturing plant runs to full capacity—at least for the units being operated—accumulates a stock if the output exceeds the sales, and closes down when business no longer justifies operation. The railroad in periods of depression must run its passenger trains even though only a few seats are occupied and at least certain of its freight trains, although they move only a handful of freight. The importance, therefore, of providing service which will enable the traffic department to sell transportation, to fill the empty seats and to give the freight locomotives a full load, cannot be overestimated.

Relation of Train Load to Cost of Moving Freight.—In recent years the value of a high train load has become to a great extent a matter of course, and many of the railroads have systematic methods of following this important feature of transportation. It is not possible to too strongly emphasize the important relation of the train load to the cost of moving freight. Fortunately methods of determining the proper tonnage ratings for locomotives have been scientifically established and are available in the proceedings of the American Railway Association and in other engineering and railroad literature, so that it is a comparatively simple matter to compute the train load for various speeds on the ruling grades and the adjustment factors to compensate from the frictional resistance of additional cars under varying temperatures.

There remains, though, the ever present problem of determining under varying traffic conditions the running time over the engine district with given speeds on the ruling grades and of ascertaining thereby the engine rating which will produce ton miles at the minimum cost. On a district having a small percentage of the mileage of the ruling grade, particularly if broken up into short sections, the locomotives can be rated for quite slow speeds on the ruling grade, say from seven to ten miles per hour, without seriously lengthening the time over the district. On the other hand, where much of the mileage is of the maximum grade the rating must be made for higher speeds on this grade in order that the time over the district will not be excessive. Of course, the amount of interference by opposing trains and by higher speed trains in the same direction on single track lines, and by important high speed trains on multiple track lines, is a limiting factor in determining the average speed over the district, and must be weighed carefully in fixing the locomotive rating. It should be realized that the economical rating of a few months ago when traffic was very thin may not be the economical rating today with the more frequent business, nor that of today the proper rating for next fall when the volume of traffic will be heavy.

On a mountain division which moves a heavy traffic, some two-thirds of which is coal, it has been found economical during periods of light business to reduce the tonnage of the eastbound trains by one-third and to use one pusher on the helper grades instead of the two required for the heavier train load. This makes practicable the closing of two helper stations and speeds up the road movement so that overtime is virtually eliminated, resulting in lower cost of handling the freight. When business is heavy though it has been found that with a given number of locomotives available a greater volume of tonnage can be moved with the heavier trains, requiring two helpers on the hills, and it has been found expedient to revert to this scheme of operation even though the cost is somewhat higher.

Systematic Classification and Through Routing of Trains.—Another feature of great importance in transporting is a definite scheme of systematic switching or classification and through routing of trains. Although offering possibilities of great economies, it has not received anything like the attention during the last decade that has been accorded the development of the train load, due doubtless to the results being of a less definite nature and more difficult to reduce to figures, and to the failure of transportation men to fully realize the advantages which follow the establishment of such a scheme. Then, too, a great deal of careful and painstaking work is required and when the plan or scheme has been developed there is need of a firm hand to supervise it and to see that there are no departures from its provisions.

Detail information as to the routing of business over and the delivery and assembling of loads and empties on each road and terminal district, the amount and character of classification already in effect at each yard, the capacity of each yard both for holding cars and for switching, the character of the traffic and the train schedules, must be gathered and prepared in tabulations, diagrams or other convenient form for analysis. And since the officer who is to work out or design the scheme should have a working knowledge of each yard and each engine district, it seems essential that he supervise and personally engage in the assembling of this information. Then, with suitable plans of the yards and terminals and track charts of all engine districts, he is in position to thoroughly analyze the problem and to draw up a tentative scheme of classification to meet both the divisional and the system requirements. After this it is advisable to call together in conference the yardmasters and the superintendents and other transportation officers in suitable groups to consider the tentative scheme and make such revisions as may be found advisable. The completed scheme should then be published in suitable form for distribution to the officers and employes whose duty it is to carry out its provisions.

The cardinal principle of systematic classification and through routing of trains is that the first classification yard that switches a car, after the bill is made and it starts on its journey, places it in the classification that will take it through to the point of delivery, or to the last yard short of its destination, without another switch. Station order switching of cars for the engine districts leading out of each yard, the classification of empty cars according to the class of car and its suitability for loading with the different kinds of freight are among its provisions. To obtain the full benefit of the through routing of trains it is advisable also to establish a scheme of car inspection and repairs by which the equipment will be in condition when loaded or when received in interchange to go through in the proper classification without being cut out for repairs. Then, with a sufficient volume of business, trains can be built up to move through terminal after terminal as "main trackers" requiring only the changing of locomotives and crews and such inspection as is necessary for detecting unsafe defects which may have developed on line of road since leaving the last terminal.

Economic Utilization of Freight Cars.—The economic or intensive utilization of freight cars embraces the principal factors of high average car mileage and high average car loading, which are to a considerable degree inter-dependent. There must be not only a high mileage per car per day but the unproductive mileage must also be reduced to the minimum. By unproductive mileage is meant the useless haul of cars, whether loaded or empty. When two or four or ten cars are used to move a shipment of freight where one or three or nine would have sufficed, unproductive mileage is made just as truly as where there is a cross-haul of empty cars suitable for the same class of loading. It is here that the feature of proper car loading comes in. By far the greatest percentage of empty mileage is not unproductive mileage, for the reason that in the nature of the traffic there is no possibility of securing a return load and the movement of the empty is an integral part of transporting the shipment. With the proper realization of this condition an analysis will show that the opportunities of reducing unproductive mileage are far less than seem to be generally assumed. On a railroad system operating in the states east of the Mississippi and north of the Ohio and Potomac rivers, under normal conditions the general movement of traffic and equipment will be somewhat as follows:

Livestock moving from the west and south to the east and north—cars returning empty; packing house products, dairy freight, fruits and vegetables moving east and north—refrigerators returning empty; coal moving from the mines in Pennsylvania, West Virginia, Kentucky and Ohio, to the east and north and to the west and north—cars returning empty except for a certain percentage used for ore, limestone, etc.; lumber, cotton, grain and other farm products, flour, feed, etc., moving east and north in such great volume that a return loading of merchandise and manufactured products is available for only a part of the box, flats and mill gondolas in which the business moves, the excess cars—a considerable percentage—moving west and south in large quantities. It would seem then that about the only way to make unproductive empty mileage is to haul empty stock cars, refrigerators or box cars east or north or to move empty coal cars away from the mining districts. And such really is the case. It is true that during the war, and the years of heavy business succeeding it, the movement of traffic was more nearly balanced and stock cars, gondolas and even flats were loaded with cement, stock cars with brick and tile, rough loading box with tinplate and other finished steel products, to quite a large extent. In fact a load could be secured for almost any car capable of being made approximately suitable even at a heavy expense. This condition reached the maximum in March, 1920, when the railroads of the country were able to reduce the empty mileage to 27.7 per cent of the total—the lowest of which there is record. But these were not normal times, nor does there seem to be much likelihood of a recurrence of the balance of traffic which then obtained.

There are a few instances of cross-haul of box cars, rough loaders being used in one direction and good tight cars in the other, causing duplicate empty mileage, but these are exceptions. During the periods when business is falling off rapidly, considerable empty mileage is made in hauling cars to suitable points for storage. Empty mileage is also made in the movement of bad order cars to convenient shops for repairs. None of this empty mileage, moreover, is unproductive mileage, for it is made in meeting situations which arise in the most practicable way. How then is unproductive mileage made? Largely through the inexperience or carelessness of agents, yard clerks and other employes who route the cars improperly.

During the extensive relocation of equipment which took place in the autumn of 1920 and the following winter, there was doubtless considerable of this misrouting, for the car service rules had been inoperative for several years, during which many new employes had entered railroad service and the personnel of the yard and station forces was untrained or rusty in the handling of cars under the rules. A year later when another relocation of the same kind but of a less extent took place, and these forces were well trained, there was comparatively little of this misrouting of empty cars. There is even greater improvement in this respect at the present time and although if all of the unproductive movements on a large railroad system could be stated in car mileage, the figures probably would be rather startling, on the other hand, if reduced to a percentage of the total car mileage, the result would seem insignificant indeed and the efficiency of car handling would be found quite high.

The attainment of a high average car mileage requires sufficient business to utilize all suitable cars, freedom from congestion in road movement, prompt handling in yards and at stations and quick loading and unloading by the shippers or the railroad's own forces. The attainment of a high average carload requires the securing of as many loads as possible in the direction of the preponderating empty movement, the distribution of the cars so as to adapt the size and capacity of the car to the character of the load, co-operation of shippers in loading the cars to either the cubic or the carrying capacity and the obtaining of such maximum loading at freight stations, warehouses and other loading points operated by the railroad.

Locomotive Utilization and Train Operation.—If the accounts of a railroad are examined it will be found that the expenses directly affected by locomotive utilization and train operation will run around 35 per cent of all expenses and 50 per cent of the cost of maintenance of equipemnt and conducting transportation. From this it is apparent that here a broad field is offered for effecting real economies. There are a great many elements or factors involved, some of which are the adaptation of types of locomotives to the requirements of the service, length of locomotive runs, the pooling of locomotives or their operation with regular or assigned crews, the manipulation of power by the chief dispatcher, and the scheduling of slow freight trains out of terminals and over the road.

Here, as in other branches of transportation work, there are many situations to be met and each requires thorough analysis to determine what is the best solution. On one division pooling will give the best results; on another the regular crewing of locomotives will be found best. The tendency of the immediate present seems to be towards longer locomotive runs in both freight and passenger service. Long runs keep the locomotives on the road and so increase the percentage of working time to the total, reduce the number of dispatchments and hence the engine house expenses. The mileage per locomotive is increased so that the same work is done by a smaller number of locomotives and in this way the cost of locomotive maintenance is decreased. In passenger service coal burning locomotives have for years been making regularly runs of 200 to 300 miles and locomotives in slow freight service 150 to 170 miles and even as high as 187 miles on a very heavy traffic division. So there is nothing new or experimental in long runs. But a very large percentage of the freight runs have been around 100 miles, ranging perhaps from 80 to 120 miles. Now modern locomotives are capable of long periods of sustained performance and the number of comparatively short runs seems to offer excellent opportunities of coupling up runs and effecting the economies thereby. A number of passenger locomotive runs have recently been lengthned on the Baltimore & Ohio R. R., the longest resulting run being from Louisville to Toledo, a distance of 330 miles, and on one division the freight locomotives are now running 258 miles where the runs were formerly one-half that distance.

In adapting locomotives to the service on various districts the problem is usually that of using those on hand to the best advantage. The elimination of light types from heavy service and of retiring them permanently or at least so long as heavier locomotives are available is of prime importance; almost equally so is the disposition of the occasional type which is unusually vulnerable and is constantly giving trouble on the road or spends too much of its time undergoing repairs. Then, too, it may be found that a certain type of locomotive will perform more efficiently and reliably in continuous service, or its weight and axle loads will meet possible restrictions, and hence is peculiarly fitted for use in connection with the lengthening of runs.

On every engine district having a heavy mixed traffic slow freight trains called during certain periods of the day will make better runs than those called at other hours. The chief dispatcher will be found taking cognizance of this and from day to day arranging the calls of slow freights accordingly. The full developments of this idea will prove of much value where a large volume of slow freight is to be moved in extra trains and can be carried a step further by making standard schedules for the movement of the trains over the district. They can be prepared in simple form, for example, giving the running time between points where operating stops are made, as at water stations, coal docks, and helper stations, and can be printed on cards of convenient size to be carried in the pocket or in the back of the time table. These schedules set the pace for the engine and train crews and give them something definite to work to in their trips over the district.

Schedules for Freight Train Operation.—Substantial results have recently been obtained by the establishment of schedules for the operation of freight trains with assigned locomotives and crews on the Chicago Division of the Baltimore & Ohio. An analysis of the traffic on the division showed an unbalanced movement, the eastbound power requirements being the greater on account of the volume of livestock and quick dispatch freight moving in light high speed trains. The westbound slow freight was being handled in trains of full tonnage and the surplus power run light. The division consists of two districts of approximately 130 miles each and the men in engine and train service live principally at the intermediate terminal, Garrett. It was determined to give trains to all westbound locomotives and runs were scheduled so as to get the power to Chicago in time to return with the eastbound movement of livestock and quick dispatch freight trains departing between 6:00 p. m. and midnight.

A brief description of one schedule will make clear the method of operation. Departs Willard 3:00 p. m.; arrives Garrett 11:00 p. m., changes engine and train crews; departs 11:30 p. m. with same locomotive and train; arrives South Chicago 7:30 a. m. Return trip—departs South Chicago 7:00 p. m.; arrives Garrett 11:30 p. m., changes engine and train crews, the men relieved having 24 hours ahead of them off duty; departs 12:01 a. m.; arrives Willard 6:00 a. m. The engine and train crews leave Willard on the schedule at 3 p. m. and arrive at Garrett 11:00 p. m., where the men are relieved and are off duty for 24 hours. The schedule requires two locomotives, four engine crews and four train crews. The men are on duty about 16 hours on the round trip and have 8 hours' rest at South Chicago or Willard and 24 hours off duty at Garrett, out of each 48 hours. The advantages are improved working conditions for the crews, running locomotives through, increasing the mileage, and eliminating the roundhouse work at Garrett, elimination of all overtime, the better movement of westbound loads and empties, the saving of approximately 150 car days per day, and the general toning up of the entire organization and performance of the division. Although this method of operation was not started until March 10, the mileage made by 10 locomotives used in the service averaged for the month 5,763 miles, the highest made by any one locomotive being 7,032 miles. This average is about 2,000 miles greater than a similar average for the month of February. The results are considered thoroughly satisfactory by the division and general officers.

The Toledo Division of the same road has recently furnished a good example of the unusual demands frequently met with in transportation. The coal production in eastern and southeastern Kentucky has been very heavy since the middle of April and a large part of the business has been routed through Cincinnati. The Baltimore & Ohio, having docks at Toledo, has received the routing of all the coal for trans-shipment via the lakes and also a heavy all-rail traffic. The division consists of a double track line from Cincinnati to Dayton—60 miles—and a single track line from Dayton to Toledo—140 miles—there being only two short stretches of double track north of Dayton. The heaviest previous business was handled in July, 1918, when 736 loads 29 empties per day were moved north from Cincinnati. During the fifteen days of May an average of 931 loads 44 empties has been moved, an increase over the previous record of 27 per cent. The southbound daily movement into Cincinnati during the same period was 233 loads 705 empties, a total of 938 cars. The movement of this heavy traffic in a very satisfactory manner has been due to the ability to dispose of the all-rail business to connections freely; the control of the lake coal by temporary restrictions when the dumping at the lake port was retarded on account of weather conditions or shortage of boats, a sufficient but not an over-supply of suitable power and the systematic classification and through routing of trains on this and connecting divisions. There are three through and one local passenger trains per day in each direction over the single track north of Dayton, two scheduled fast freights and one local freight. From 17 to 21 trains per day have been required to move the freight tonnage north from Cincinnati.

Durability of Treated Ties on C. B. & Q. Ry.

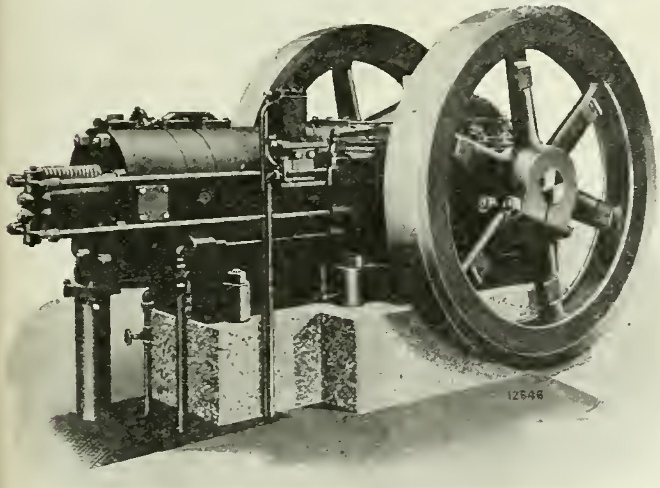
The annual inspection of more than 25,000 ties in test tracks on 20 divisions of the Chicago, Burlington & Quincy Ry., located in eight states, last fall showed that 88 per cent of the untreated ties in these sections had been removed on account of decay, after 12 years' service in contrast with 1.6 per cent of those treated with creosote, 4.4 per cent of those treated by the Card process (creosote and zinc chloride) and 12 per cent of those treated with zinc chloride. These results were obtained with 20 different species of wood. The results of these tests to date are summarized as follows in the Railway Age:

SUMMARY.
(Regardless of Species.)

	.Total ties placed in track.	Total removed to date.	Percentage removed account decay.	Percentage removed account other cause.
Straight creosote	3,261	198	1.6	4.5
Card	15,846	2,618	4.4	11.5
Burnett	2,492	619	12.0	13.2
Untreated	3,263	3,106	88.0	7.1

New Oil Engine and Its Application to Air Compressors

A horizontal direct-injection oil engine has been placed on the market by the Ingersoll-Rand Co., New York. The engine employs the Price system of fuel injection which eliminates the need for a three or four stage 1000-lb. pressure injection air compressor with intercoolers. A pump of single design provides the force for introducing the fuel into the combustion chamber. Two spray nozzles are employed and are so arranged that their sprays impinge. The manufacturer lays great stress on the fact that the head and combustion chamber are shaped so that their surfaces are at all points parallel to the sides of the fuel sprays. The object of this is to prevent the fuel fog from coming in contact with a metallic surface where it would collect as drops and result in imperfect combustion. The Price oil engine is to all intents and purposes a Diesel engine. The elimination of the air compressor, however, has resulted in a saving in mechanical efficiency of 10 to 12 per cent. With the Price oil engine, it is stated, fuel consumptions of .38 or .39 lbs. per brake horsepower hour can be gotten witb ease. The former figure means that 20-hp. hours can be obtained from a gallon of standard fuel. Ignition as in the air injection Diesel engine is obtained by the heat of compression. All parts of the head, combustion chamber, and cylinder which are exposed to the gases of combustions are completely water-cooled. No flames, coils or exterior heating devices of any sort whatsoever are required either in starting or during operation.



Price Type P. O. Oil Engine.

The Ingersoll-Rand Co. has applied the engine to compression operation and has placed on the market a direct-connected oil engine air compressor unit. The unit of which the 100-hp. engine forms the prime mover has the air cylinder in line with the power cylinder but on the opposite side of the crankshaft. For 100-lb. pressure, a two-stage air cylinder is offered. The air intercooler is mounted below the air cylinder and forms a support therefor. For air pressures less than 100 lbs., a single stage air cylinder is offered, which is connected to the oil engine frame by a distance piece. For both single and two-stage work, the air cylinder is double-acting which has contributed to the exceptional balance of the machine. In the 50-hp. size, the air cylinder is vertical and is mounted on top of the engine, immediately above the crankshaft. By so doing, it has been made possible to mount the unit on a flat car or truck for use in portable work. It is interesting to note that this construction has not resulted in excessive height—this having been kept less than 8½ ft.

Examination for Valuation Engineer.—The U. S. Civil Service Commission, Washington, D. C., announces an open competitive examination for valuation engineer. Vacancies in the Technical Staff of the Income Tax Unit of the Bureau of Internal Revenue, Treasury Department, Washington, D. C., at $3,600 to $4,800 a year, and in positions requiring similar qualifications, at these or higher or lower salaries, will be filled from this examination. Applications will be received until Oct. 6.

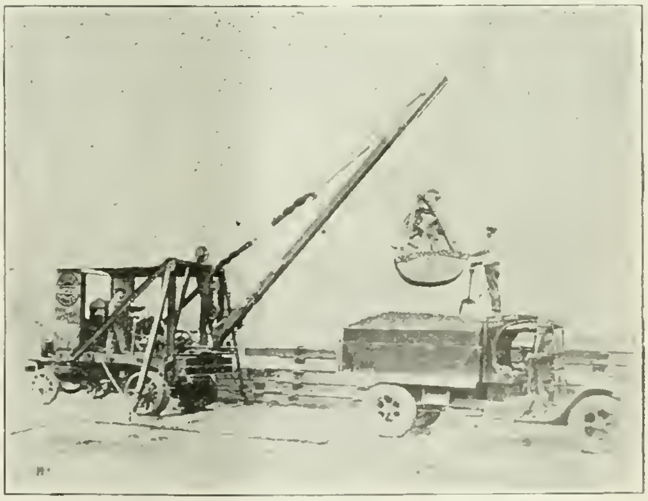
Hauling Trees for Current Retards with "Caterpillar" Tractors

Two "Caterpillar" tractors are being used by the Woods Bros. Construction Co. to snake trees from the bottom land timber sections to the bank of the Missouri River, where current retards are being built, for the purpose of river bank protection. At Dakota City, Neb., where 20 of these retards are being constructed, a 5-ton "Caterpillar" drags the trees as they are chopped, through the heavy underbrush to an opening, or to a convenient roadway. Here the trees are bunched, loaded on a special 2-wheel Lufkin cart and hauled by a 10-ton "Caterpillar" two and three miles to the river. Two construction gangs, of seven men each, are kept busy, each gang with a steam hoisting engine pulling the trees into the river to make current retards. The tractors work day and night, averaging more than 20 hours out of the 24-hour day. The trees are hauled in numbers from three to eleven trees per load. No trimming is allowed, the limbs, branches, leaves, and trunk being dragged bodily. According to observation of a typical 2-mile haul, the 10-ton "Caterpillar" makes 9 trips in a 10-hour day, and with the loads, that the 5-ton brings to the river on its way to the camp, at noon and night, 60 trees are delivered. Trees of all sizes are hauled, the average being more than 12 in. in diameter. Previous to this, the work was done with horses. There were five teams, four horses to the team, and the best any one team could haul in 10 hours was seven trees, or a total of 35 trees for all teams.

Tractor Dragging Trees.

Motor Truck Mounting for Byers Crane

A crane that can be mounted permanently on a motor truck has been brought out by the Byers Machine Co. of Ravenna, O. The new outfit, called the "Byers Truckrane," can be driven from the garage to the job every morning, or driven from one job to another with a minimum of time lost in travel. The crane, unmounted, weighs only six tons, and is similar to the Byers Auto-Crane Model "1" in every respect except that it has no wheels, jack shaft, nor differential



"Truckrane" Owned and Operated by The Worth Motor Service Co., Chicago.

and drive chains. It has a power drum for raising and lowering the boom which is of steel. The crane is furnished with a Hercules 4-cylinder 4-in. x 5-in. engine developing over 30 H.P., to be operated with gasoline power. Any $\frac{1}{2}$ cu. yd. bucket weighing not over 2,000 lb. can be used with it. It is not at all necessary to use a new truck for the mounting. One that has seen 90 per cent of its usefulness, having a motor that is capable of turning over, is all that is needed. The Byers Co. has already started the erection of additional buildings and machinery required to manufacture the "Truckrane" on a large production basis without any interference with the standard lines of "auto-cranes," revolving cranes, and hoists.

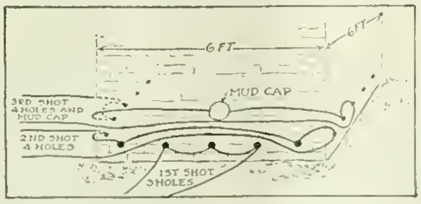
Blasting Down a Brick Smokestack

A difficult job of chimney demolition was successfully carried out at Glen Gardner, N. J., by the use of explosives. An old factory chimney, 80 ft. high and 6 ft. square at the base had become a menace to adjacent buildings and it was necessary to remove it.

Holes 1$\frac{3}{8}$ in. in diameter, spaced 12 in. apart, were drilled 18 in. into the base of the stack on three sides. The position of these holes and the sequence in which they were loaded and fired are shown in the accompanying sketch. Because the walls were so badly cracked, and the hood particularly, there was a possibility that the shock of exploding dynamite might cause the stack to split in half and fall contrary to the plans. On this account more than ordinary care and good judgment in loading the holes was exercised. It was not desired to shake the stack too hard, even though it was necessary to blow out enough space with the first shot to make a safe place for loading the second round.

The Old 80 Ft. x 6 Ft. Stack.

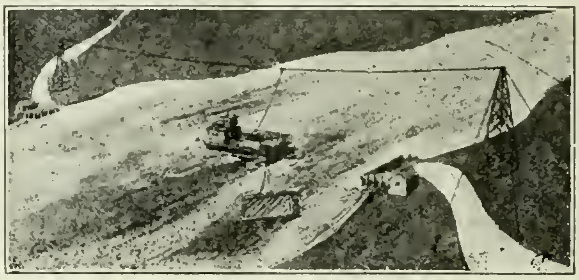
One-half stick of dynamite was loaded in each of the three holes and fired electrically. This first round did its work and the second round of four holes was similarly loaded and fired, further weakening the base of the stack on the side toward which it was destined to fall. The third and final round consisted of four holes each loaded with a half-stick of dynamite and an additional 2-lb. mudcap charge placed in the center. When this shot was set off, the stack, still intact, began to lean away from the building, then, gathering momentum, it fell swiftly into the open field. Felling this stack required in all 6 lbs. of 30 per cent Red Cross Extra dynamite. The total cost for the explosive and blasting caps was less than $3.00, according to The DuPont Magazine, from which this note is taken.



Sketch Showing Position of Holes and Order in Which They Were Loaded and Fired.

A Current Driven Ferry

A ferry boat operated on the "river kite" principle* was described in The Crosby Clipper, from which the following account is taken. This ferry plied back and forth across the Missouri River at Chamberlain, S. Dak., and was in service for considerable time. The boat was held to its course by an aerial cableway strung between 60 ft. high timber towers on opposite banks on the river. A trolley ran back and forth on the aerial cable and was connected to the ferry by another cable. Crosby clips were used to make all the fastenings of the cableway, including the guys which steadied the towers. The unusual feature of the installation was the method of using the swift current of the river to propel the ferry across the channel. This consisted of a timber raft with the timbers arranged diagonally so as to deflect the current and, in conjunction with the restraining influence of the trolley cable, to exercise a forward pull in the raft When it was desired to recross the river the raft was flopped over, deflecting the current in the opposite direction, and pulling the boat back across the river.



Sketch of Ferry in Operation.

Where the current was swift this "current motor" was quite successful, and the ferry was pulled rapidly across the stream, but when a "dead" spot was encountered it was necessary to fall back on a gasoline engine which had been installed as an auxiliary power plant. The fact that the current was not strong enough at all times to propel the ferry all the way across the river, and that even at best it was strong in some spots and weak in others, led, eventually, to the discarding of the towing raft, and the installation of a paddle wheel driven by a 30 h.p. gasoline engine.

Personals

Leonard B. Hiebel has been appointed city planning engineer of Akron, O.

F. J. Haagan, Huntington, Ind., has been appointed division engineer of the Huntington and Chicago divisions of the Erie R. R., with headquarters at Marion, O. H. D. Row will become division engineer of the Cincinnati division, with offices at Marion.

Harrison F. Gonnerman has joined the staff of the Structural Materials Research Laboratory, Lewis Institute, Chicago. Mr. Gonnerman graduatad from the Engineering College of the University of Illinois in 1908; from 1908 to 1914 he was assistant instructor in the College of Engineering, University of Illinois; 1914 to 1920, research associate in the Illinois Engineering Experiment Station on experimental studies of concrete and reinforced concrete under the direction of Prof. A. N. Talbot. During the past two years he has been in business in Los Angeles. Mr. Gonnerman is author of a number of papers before the American Society for Testing Materials.

Obituaries

George Bode, contractor, of Youngstown, O., died Sept. 8, aged 64 years.

James Comiskey, Sr., contractor, died Sept. 6 at his home, 370 Custer Ave., Youngstown, O., aged 45.

Harry S. Reukert, president of The Metropolitan Paving Brick Co., Canton, Ohio, died at Geneva, Switzerland, on August 20.

Industrial Notes

F. A. Wickham, 3134 Emerson Ave., South, Minneapolis, Minn., has resigned his position as general manager of the Glide Road Machine Co., Minneapolis

Scheid Engineering Corporation, 90 West St., New York City, has been appointed metropolitan and export representative for the Franklin Moore Company, Winsted, Conn., manufacturers of material handling machinery for industrial plants.

The Conveyors Corporation of America, 326 West Madison St., Chicago, has appointed the Mid-West Engineering Sales Co., Masonic Temple, Cedar Rapids, Iowa, representatives in eastern Iowa for the sale of American Trolley Carriers, which is coal handling equipment of the monorail type.

By mutual consent, the copartnership consisting of Benjamin F. Klein and William J. Schoenberger, trading as the United Brass Manufacturing Co., located at 3844 Hamilton Ave., Cleveland, O., has been dissolved, effective Sept. 1, 1922. The United Brass Manufacturing Co. continues as heretofore in the manufacture of plumbing brass goods and water works brass goods at its present location, under the sole ownership of Benjamin F. Klein. Wm. J Schoenberger withdraws and takes over the gas valve and stove cock department, which will be operated by The W. J. Schoenberger Co., located at Harvard Ave. and 103rd St., Cleveland, O., manufacturing brass gas valves, gas cocks and special fittings for gas appliances.

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*A description of the "river kite" and its application was given in the June 10, 1917, issue of Engineering and Contracting.

Buildings and Structural Issue

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Roads and Streets—1st Wednesday
- (a) Roads
- (b) Quarries and Pits
- (c) Streets
- (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
- (a) Water Works
- (b) Irrigation and Drainage
- (c) Sewers and Sanitation
- (d) Waterways

Railways—3rd Wednesday
- (a) Steam Railway Construction and Maintenance
- (b) Electric Railway Construction and Maintenance
- (c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures

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If Andrew Had Organized the Carnegie Libraries Co., Ltd.

"Merely as a university of business, therefore—as a place where men may read and think under sympathetic guidance—the public library deserves a lot more attention than it ordinarily receives at the hands of business men. . . . My hope for the large service of the libraries rests largely on my knowledge of what the library can do for the average man in business, if he will only give it a chance. Once let him discover that the public library can help him do business more efficiently and profitably and he will act."—John Cotton Dana.

Mr. Dana is perhaps the oldest librarian in America. At any rate he has excelled all others in making a public library a "university of business," a place where men can find information aidful in earning a better living. But as we read the interview from which our opening paragraph is an abstract, we wondered whether Mr. Dana might not have accomplished vastly more had there been no public library in Newark, where he lives, or in any other American city. The thought is odd, but let us follow it out.

Suppose Andrew Carnegie, having sold his steel plants, had decided to make a business of renting books and magazines, and had employed John Cotton Dana as president of the Carnegie Libraries Co., Ltd. Suppose Carnegie had said to Dana:

"I believe that what men most lack is the knowledge already possessed by a few men. Burbank, in his great book, tells us that if the average American farmer used the best known agricultural methods and raised the best known plants, half as many men as are now engaged in agriculture could raise all the food that is now produced. Taylor, in his 'Scientific Management,' has made a similar statement as to a machine shop production. In fact, the leading experts in every line of productivity have statistical evidence that the ablest producers are twice as efficient as the average producer, and that their methods are teachable. Believing this to be so, and believing that by the aid of books and articles the best methods of production, transportation, marketing and finance can be made known to all directors of economic affairs, I have decided to invest my fortune in a plant designed to make economic students of all these directors or leaders. To accomplish this purpose, I plan to build and equip a chain of libraries, and to advertise their wares, just as the goods of chain stores are advertised. In charge of each library I plan to have a librarian whose income will be proportional to the profit that he can show from the rental of the books and magazines. Your income, Mr. Dana, will likewise be dependent on the profit of the Carnegie Library Co., Ltd. Your income may eventually exceed a million dollars annually. While I believe that you would give the best that is in you for a small fraction of that income, I realize that you are an exception to the rule that great profits stir great ambitions. I want to attract into this library business the ablest and most ambitious men in America, and I plan using the same methods that enabled me to surround myself with the ablest steel producers, men of the caliber of Charlie Schwab, men who desire great incomes not for the pleasure of spending but for the pleasure of controlling vast organizations.

Hitherto the library business has been a miserable failure, taking it as a whole, not because it has lacked a service that should be salable, but because it has lacked great salesmen. No product can be sold adequately without salesmanship, and that means advertising as well as word of mouth persuasion. Men must not be given merely a chance to discover what a library contains. They must be made to see what it contains, and this can be accomplished in a great way only by advertising and salesmanship. Millions of men carry life insurance policies not because they discovered the value of doing so, but because advertisements and sales agents forced them to see the wisdom of insuring their lives.

Libraries must be managed as business institutions, not as charities supported by donations and taxes. Their service is the greatest that can be offered. I want you to sell to Americans that incomparably valuable thing called economic knowledge. My millions are ready to buy and equip the plant, but I expect those millions to earn a profit that will be used to enlarge the business, and thus to carry education to every man, woman or child in whom a responsive chord of desire for progress can be made to vibrate."

Who that knows the power of profits as an incentive to action can doubt that had Carnegie adopted some such plan as that suggested, his millions would have been vastly more efficacious than they have been. He has builded book-filled mausoleums to perpetuate his memory. Would he have not secured a greater and a longer heritage of fame had he builded a business in book renting comparable to the business of steel making to which his life was devoted?

The Prospect of Perpetual Timber Farming on the North Pacific Coast

The western slope of the mountain chain of Oregon and Washington is destined to become a great "farm" for the raising of timber. The steep slopes unfit the land for agriculture, but the mild temperature and great rainfall make it ideal for forest growth.

The U. S. Forest Service is about to offer for sale the annual timber crop of the Bear Valley unit of The Malheur National Forest in Oregon. It is estimated that an 80-mile railway and mill costing $3,000,000 will have to be built by the close of the first operating year. A mill cutting 60 million feet a year will be able to operate forever, thus presenting the unique spectacle of a permanent lumber camp.

The entire Pacific slope from Oregon to Alaska is an ideal region for the perpetual raising of crops of timber. We doubt not that eventually the greater part of this area will be used as a timber farm.

The Panama Canal makes it economically possible to ship this timber to Atlantic ports. So if the American and Canadian governments undertake to reforest the cut-off areas, there is no doubt that lumbering will always remain one of the greatest industries of the north Pacific region.

The Eskimo as a Structural Engineer

Have you seen "Nanook of the North," a moving picture of Eskimo life? There is one scene particularly interesting to an engineer or architect. We refer to the building of an igloo by Nanook. The house is made of blocks of ice or of congealed snow so laid in a spiral and leaning inward, so as to form a dome-shaped structure. In his lecture on "The Far North," Stefansson has paid a great compliment to the original designer of this serviceable residence. He said that although many white men had attempted to build igloos, none had succeeded until taught by an Eskimo. When Peary made his celebrated dash for the North Pole his party lived in silk tents and almost perished from cold. But when Stefansson made an equally long trip north of the Arctic circle, he built an igloo every night, and slept in comfort at a temperature of 60 degrees.

Consider the igloo as an economic structure. The materials are compacted snow or ice—nothing else. The structure is large enough to house a dozen people comfortably. It can be erected in an hour by three men. Its dome shape makes it not merely self-supporting but capable of carrying all the snow that may heap upon it. A hurricane will not blow it over. Its walls are comparatively poor conductors of heat, so that the heat from a few pounds of seal blubber serves to maintain a comfortable temperature all night, although the outside air may be 40 degrees below zero.

"Some" structural engineer was the man who designed the first igloo.

"Own Your Home" Presented in Movies

In various parts of the country, particularly in Ohio and California, model homes have been constructed with the idea in mind of stimulating an interest in home building. These model homes have created a great deal of interest locally, but have done little nationally.

The demand for some method of giving national scope to this movement finally resulted in the Atlas Educational Film Co. of Oak Park, Ill., being commissioned to produce a five-reel feature film showing the erection, equipping and furnishing of a modern six-room, brick, colonial home.

This film will be shown all over the country under the auspices of and with the co-operation of real estate boards, commercial, advertising, rotary, Kiwanis, Lions and other clubs and organizations; also through official government non-theatrical distribution bureaus (one located in almost every state, usually the state university), through churches, community centers, etc. At present bookings have been requested in practically every large city and town. It is desired that interested parties arrange bookings as soon as possible. All bookings and arrangements can be made directly with the Atlas Educational Film Co. of Oak Park, Ill. In the case of various clubs, real estate clubs, etc., only a very nominal charge will be made to cover the renovating and circulation of the films.

The proposition is being financed to a large degree by the various manufacturers whose products are used in the construction of the model home.

Wash Boring Outfit for Determination of Bridge Foundations

The Bridge Department of the State Highway Department of North Carolina has effected a considerable saving in determining the character of bridge foundations by the use of a wash boring outfit, designed by H. C. Scott, construction engineer of the commission, and built at its shops. The following account of the outfit is taken from article by P. K. Schuyler in the North Carolina Highway Bulletin.

The apparatus consists of a 2 in. casing pipe which is driven into the ground by a 120 lb. hammer pulled up by hand in a set of 16 ft. leads and allowed to drop. Inside of this casing pipe is a wash pipe ¾ in. in diameter through which water is forced under 30 lb. pressure by a 2-h.p. gasoline engine. The material is washed up between this pipe and the casing and is caught in a bucket or some vessel for examination. The outfit is transported from place to place in a "G. M. C." light aviation truck, rigged up especially for this purpose. Practically all of the material used in the construction of the outfit was obtained from surplus war material allotted to the state from the federal government.

The truck in which it is transported was also allotted to the state from surplus war supplies. The total cost of operation, including all overhead expenses, runs about 75 ct. per lineal foot of boring up to 50 ft. which is the greatest depth that the machine is capable of boring. The gang required to run the outfit consists of an engineer in charge, a truck driver, who also operates the pumping engine, and two laborers who are obtained locally. One boring requires about one day, much of the time being consumed in unloading and making the set up.

Slight Increase in Structural Steel Sales in August.—Sales of fabricated structural steel in August showed a slight increase over the low figure reached in July. August sales amounted to 65.2 per cent of shop capacity, compared with 62 per cent in July and 72 per cent in June. Reports have been received from 125 firms for each of the 5 months April to August, inclusive. Those 125 firms report a total shop capacity of 208,245 tons per month. The actual sales for the past 5 months reported by these 125 identical firms have been as follows:

Month, 1922.	Tonnage booked.	*Per cent of capacity.
April	181,947	87.4
May	165,272	79.4
June	149,907	72.0
July	129,160	62.0
August	135,843	65.2

*The inclusion of additional firms this month has made slight revisions in the per cent of capacity reported previously.

Standard Zoning Law.—A standard law for the assistance of those responsible for the framing of state zoning enabling acts has just been issued by the Department of Commerce. Zoning ordinances for the regulation of use, height and area of buildings are being adopted by cities in almost every state in the Union, and in some states where there is no specific authority for zoning these ordinances may be set aside by the courts. An enabling act is advisable in all cases. The Department of Commerce model for an enabling act under which municipalities can adopt zoning regulations is a twenty-page, mimeographed document with foot notes covering questions which might arise in the wording of various sections and provisions.

Biographical Data Wanted of Early American Structural Engineers

To the Editor: As a matter of important record and to illustrate the "Scope of Work of the Structural Engineers," we desire to secure biographical data pertaining to the early American structural engineers, who died without leaving the public available records of their life's work.

One of the few early engineers whose biography is available is that of Benjamin Henry Latrobe which was edited and published by J. H. B. Latrobe in 1905, a brief sketch of which is given below to indicate the scope of work of the structural engineer in the early times.

Many such engineers were engaged on the most prominent work in the building of this country before Civil War times and are now lost in oblivion, unless those now living and engaged in structural engineering, who have information regarding such early engineers will compile the data necessary to prepare biographical sketches.

To illustrate, who can discover the biography of John W. Nystrom, who was the author of "Nystrom's Mechanics," published in 1854 which in the writer's opinion was the model used for the first "Carnegie Handbook."

Therefore you are requested to furnish this association with such data as you can pertaining to the principal work of the early engineers as you may have knowledge about, which will be compiled for a permanent record.

This information will be used to educate the public as to the scope of work of the structural engineer, and in demonstrating that the structural engineer is the development of an old profession and is not a new profession which perhaps encroaches on the rights and privileges of another profession.

Your co-operation in collecting such biographical data will be appreciated whether you are a member of this association or not. Please advise us of such of the early engineers of whom you have information.

STRUCTURAL ENGINEERS ASS'N OF ILLINOIS,
John P. Cowing, Secretary.
30 North La Salle St., Chicago.

BIOGRAPHICAL SKETCH NO. 1.

"EARLY AMERICAN STRUCTURAL ENGINEERS."

BENJAMIN HENRY LATROBE, engineer, was born in England in 1767, but was educated at the University of Leipsic from which he graduated in 1785 and obtained a commission in the Prussian Hussars. In 1787 he returned to England and entered the office of one of the best architects in London, shortly afterward being appointed surveyor of public buildings in the city of London In November, 1795, he sail for America and arrived at Norfolk in March, 1796. After a short stay in Norfolk, he went to Richmond where he resided until 1798, when he moved to Philadelphia and was the first to supply Philadelphia with water pumped by steam from the Schuylkill in 1800. In Baltimore he was the architect of the Roman Catholic cathedral and the cutsom house. Thomas Jefferson appointed him surveyor of the public buildings in 1803 to follow Thornton, Hatfield and Hoban, as architects of the capitol, and he perfected Dr. William Thornton's designs and altered those for the interior construction of the south wing, with the approval of the President. Of this the corridors and the committee rooms, the stairs and the lobby with its panelled dome escaped the flames when the capitol was burned by the British in 1814, and still remain. In the construction of the north wing Mr. Latrobe planned a vestibule in which are six columns, each of which is composed of Indian cornstalks bound together, the joints forming a spiral effect, while the capitals are modeled from the ears of the corn. This forms a unique order of architecture, which he regarded as purely American. Jefferson has been considered by many to be the designer of these pillars, but that Latrobe was their originator is proved by his letter to Jefferson dated August 28, 1809, in which he says: "These capitals during the summer session obtained more applause from the members of congress than al lthe works of magnitude or difficulty that surrounded them. They christened them the 'Corn-Cob Capitals'—whether for the sake of alliteration I cannot tell, but certainly not very appropriately." He also designed the tobacco-plant capitals of the columns in the circular colonade in the north wing, and left drawings of a capital whose ornamentation is designed from the cotton-plant. He was the first to utilize the Brecca marble of the Potomac in the columns in the house of representatives and the senate chamber. His suggestions as to the use of natural products as a feature of architecture was followed by his successors. Mr. Latrobe was also engaged as engineer in constructing the original plan of the Chesapeake and Delaware canal, residing alternatively in New Castle and Wilmington until 1808, when he removed to Washington with his family. In 1812 he became interested with Fulton in the introduction of steamboats on the western waters, and built the "Buffalo" at Pittsburgh, the fourth steamer that descended the Ohio river. After the burning of the capitol, Mr. Latrobe was called to rebuild it. He resigned this post in 1817 and was succeeded by Charles Bulfinch who executed Mr. Latrobe's designs in changing the oblong hall of the old capitol into a semicircle.

As structural engineer to the navy, he designed and executed the navy yard at Washington, its buildings and machinery, various buildings at the New York gosport, and Pittsburgh navy yards, and the marine hospital. In addition to his skill as a structural engineer Mr. Latrobe possessed remarkable mechanical genius and designed, among other things, a rolling mill for iron, steel and copper at Philadelphia, improvements of cotton machinery, improvements of sugar machinery, corn kilns for drying the grain, the steam engine, fire tube and water tube boilers, a floating battery propelled by steam and using a horizontal fly-wheel to keep the machinery below the water line. Together with Fulton he designed a boat carrying guns in her hold to shoot under water, improved Fulton's torpedo, worked with Jacob Perkins on his electric torpedoes or mines, built Mississippi river steamboats at Pittsburgh, and was connected with Nicholas I. Roosevelt, who early demonstrated the practicability of the steamboat. In 1804 he offered with Roosevelt to build a stone bridge from "New York to Long Island, crossing Blackwell's Island" for $950,000.

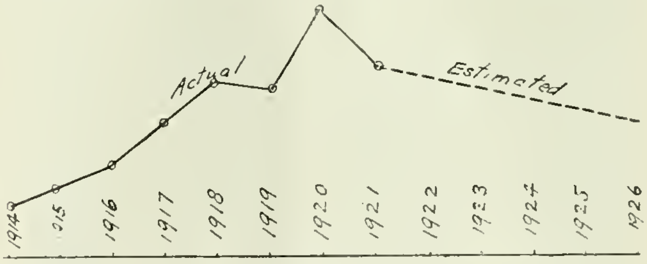
At the time of his death, September 3rd, 1820, he was engaged in building a water works system to supply New Orleans, La., with water.

Future Course of Prices in Europe

To the Editor: There is an interesting question in Economics to which some sort of an answer can be given from a consideration of the principles outlined in one of your articles.

The question is, "What is likely to be the future course of prices in Europe?" The article is that contained in your issue of April 7, 1920.

The formula in that article is applicable to Europe as well as to this country, being general. Taking up the factors one by one as they apply to Europe, or rather, for greater clarity, to the average prices in the three countries, England, France and Italy, consider first population, and instead of population we may say effective workers. The number of effective workers is likely to increase since the ranks of working men were depleted by the war and the coming of age of boys each year will raise the number of workers who are effective. In the next place the productive efficiency will increase as more settled conditions gradually come about and men get into kinds of work for which they are adapted. The third factor, currency in circulation, will grow less since all these countries have had inflation and past experience has shown that more prosperity results when a country has a well secured currency and as these are old countries they will profit by that experience of long ago and gradually reduce their currency. The fourth factor, rate of turnover, may remain stationary, or may slightly increase.



Actual and Estimated Trend of Prices in Europe.

Three out of four of the factors then will operate to decrease prices; no attempt will be made to say how much prices will fall but probably it will not be very much, since at times currency may be slightly increased.

The maximum amount of currency in circulation was reached some time ago in both England and France.

The foregoing is an attempted forecast of the future. As a record of the past the following figures of the average price index number for England, France and Italy may be given:

Year.	Price index.	Year.	Price index.
1914	100	1918	324
1915	131	1919	318
1916	183	1920	472
1917	255	1921	368

I venture the prediction that, influenced by the competition of Europe, average prices in this country will be lower five years from now than they are today.

JOHN WILKES,
Nashville, Tenn. Civil Engineer.

Fire Tests of Gunite Walls

Fire tests of walls built of gunite have been made by the Underwriters' Laboratories, Chicago, and are described in a report issued by the laboratories under date of May 12, 1922. In this work the regulations of the underwriters as well as of the fire prevention committee of the American Concrete Institute provide that two samples must be tested, one to be subjected to the standard temperature curve, which calls for a heat of 1,000° F. in 5 min.; 1,300° F. in 10 min.; 1,550° F. in 30 min.; 1,700° F. in 1 hour; 1,850° F. in 2 hours, and 2,300° F. in 8 hours, sample to remain subjected to the heat until such time as the temperature on the side away from the flames shall reach 300° F., at any point. Another sample shall be similarly prepared and subjected to the standard heat for a period of 1 hour at which time it shall be immediately removed from the furnace and subjected to a stream of cold water applied at from 60 lb. to 80 lb. pressure from a fire hose for a period of from 3 to 8 minutes.

The first of these tests is known as the fire endurance test, and the second as the fire and hose steam test, and the acceptance and rating of any wall is based on its ability to withstand (1) the passage of flames; (2) resistance of decalcination or dehydration; (3) capability of restoration after a fire; (4) the period of resistance of the passage of heat; (5) resistance to destruction from impact or similar causes.

In regard to the fourth provision there is a regulation of the various bodies to the effect that a time rating is given of 80 per cent of the period elapsing before the temperature of 300° is reached on the unexposed side, as it is generally recognized that when this temperature is reached there is danger of spontaneous combustion of materials away from the exposure and adjacent to the wall.

The Walls Tested.—The walls covered by this report consisted of a single wall of gunite about 1 in. thick supported by 2 in. x 4 in. wooden studs spaced about 16 in. on centers; a single 2 in. wall of gunite with supports at intervals of from 4 ft. to 7 ft., and a double wall consisting of two 2-in. gunite walls, connected at intervals of from 5 ft. to 7 ft. with solid gunite studs. All walls were reinforced with expanded metal.

In the investigation of the single 1-in. wall the fire and hose stream test sample was subjected to the standard heats (maximum 1,500° F.) for 36½ minutes and to a water test of 3 minutes, and the report states:

"The panel was securely in place at the end of the test and still capable of preventing the passage of flame through or around the wall. The gunite slab had separated from the wood studding so that the nails near the middle of the studs were generally drawn clear of the studs over the center region of the sample. The outer surface of the gunite was somewhat dehydrated, but in general the dehydration did not extend through. The outer surface of the studs were charred quite generally and the felt carbonized except in places."

In the panel to be subjected to the fire endurance test it is stated that "it was early noted that the nails holding the mesh to the studs did not pull with the expanding slab, resulting in a spalling of the slab to such an extent as to allow the passage of flames," with the result that the fire was withdrawn at the end of 32 minutes. The report in referring to this phase of the investigtaion states:

"In the single test in which no spalling occurred the gunite and expanded metal drew away from the wood studding by pulling the nails which held the expanded metal to the studding. When it is considered that the nails are 3 in. long and spaced comparatively closely together the force developed by the expanding gunite and reinforcement may be realized."

Test of Hollow Double Wall Type.—The other samples tested at the laboratories consisted of two slabs of the hollow double wall type each about 10 ft. wide by 11 ft. high. The studs were spaced on 6 ft. 10 in. centers thereby leaving a short space of about 18 in. on each side adjacent to the brick enclosure walls. The sample subjected to the fire and hose stream test was withdrawn from the flames at the end of the specified hour duration; while the fire endurance test sample remained exposed to the flames for a period of 4 hours and 15 minutes, at which time one of the thermometers on the unexposed face reached 340° F., although the average temperature of the five points was 263° F. at that time. The heat of the exposed face at the time was about 2,030° F.

No tests were made by the laboratories on single 2-in. walls, but as the authorities of Columbia University were preparing tests on gunite slabs (A) 1½ in.; (B) 2¾ in., and (C) 2¼ in. thick it was arranged to carefully study and co-ordinate these results with those obtained at the laboratories in order to incorporate this information in the report. These slabs were designed and reinforced to support loads of 40 lbs. per sq. ft., on a 6 ft. 3 in. span, Slab A; 150 lbs. per sq. ft. on 8 ft. 6 in. span, Slab B, and 150 lbs. per sq. ft. on a 6 ft. 10 in. span, Slab C. Temperature readings on the top and bottom of the slab were carefully measured. The heat of the exposed side closely approximated the standard curve until it reached 1,700° F. when it was kept at that temperature for the period of the test (2 hours 56 minutes). The unexposed face of Slab A which was 1½ in. thick reached a temperature of 300° F. at 1 hour and 44 minutes, while Slab C (2¼ in. thick) reached the temperature at 1 hour and 52 minutes.

It had been the original intention to subject all of these slabs to an exposure of 1,700° F. for 4 hours, but at 2 hours 56 minutes a hole about 24 in. in diameter broke through Slab B, resulting in drawing the fire. Examination of the stresses showed that the steel reinforcing mesh in this slab was subjected to a strain of 19,400 lb. per square inch under the imposed load of 150 lb. per square foot, and as the failure was clearly in the melting of the steel it would seem to indicate the inadvisability of designing slabs of this type with such high stresses. After the slabs had been allowed to cool, Slab A was loaded to 200 lb. per square foot and Slab C to 600 lb. per square foot, both without destruction.

The Impact Test.—A very interesting phase of this investigation was the impact test to which the two double wall samples were subjected. A standard 15 ft. I-beam 16 ft. long was provided with standard connecting angles on the head, and so placed that a hinged footing at the floor was 13 ft. from the wall. This allowed the head of the beam to fall freely against the wall without rebounding, it being thought to approximate as nearly as possible falling beams in case of fire. It is interesting to note the summation of these tests as noted in the report.

"The results obtained in these tests show that gunite double wall construction is capable of resisting fairly heavy impacts from falling members without the formation of openings through back slabs, and that it possesses this property after it has been exposed to severe fire for fairly long periods. The heavy reinforcement employed yields sufficiently to absorb much of the impact and at the same time offers sufficient resistance to prevent the falling members from penetrating deeply into the wall. The reinforcement also serves to transmit the force of the impact to surrounding areas. The reinforcing studs present a high degree of resistance to impacts, and are so protected by the slabs that they are not easily affected by heat. The combined resistance of the reinforced gunite slabs and gunite studs increases the impact resistance of both of these parts."

Philadelphia Building Congress Formally Organized.—At a meeting Aug. 17 in Philadelphia of the Construction Conference Group which has for two years past been functioning informally along lines conforming to the activities of the National Federation of the Construction Industries and latterly of the New York Building Congress, the Group formally completed the organization of the Philadelphia Building Congress. The objects of the organization as stated are "to enable the building and construction industry to promote the general welfare—by discovering, through scientific surveys, the needs of the public and of the industry; by finding and recommending ways and means of satisfying those needs; by defining group functions and harmonizing group activities through the formulations of codes of ethics and of practice for the industry, and by other means agreeable to and in the interest of the public and the industry and conformable to law." Officers were elected as follows: President, D. Knickerbacker Boyd; vice-presidents, James W. Pearce, Edwin L. Seabrook, Harry C. Woods; secretary, H. J. Baringer; treasurer, Herbert L. Towle.

Tests of Concrete in Sea Water

Early in 1909 the Aberthaw Construction Co. of Boston, Mass., began some tests to ascertain the effect of sea water on concrete. A series of 24 test specimens, 16 in. sq. by 16 ft. long, were made of various qualities of cement. Three different preparations of cement, sand and broken stone, and three different quantities of water were used. Three specimens were made during the first two weeks of January, 1909, and were immersed in the sea at the Charleston (Mass.) Navy Yard in February, 1909. They were suspended so that more than 3 ft. of each specimen at the top would seldom be wet and, presumably never be immersed, while about 3½ ft. projected below mean low water, and therefore, would never be uncovered.

Details of the construction, the progress and reports of the condition of the specimens were given in the May 6, 1914, and March 3, 1921, issues of Engineering and Contracting. In a paper presented June 21 at the annual convention of the American Society of Civil Engineers, Mr. L. C. Wason, President of the Aberthaw Construction Co., gives some further data on the results of the tests. We quote from his paper as follows:

After 13¼ years of study of these specimens, the writer believes it is possible to make some tentative deductions on the cause of failure and suggestions for design so as to make future structures as nearly as possible proof against disintegration by sea water.

The conditions in Boston Harbor are probably as severe as in any harbor of the United States. The specimens are subjected to considerable tide run, attacked by waves, abrasion from floating objects, freezing during severe winters, and attack from impurities, chemical or otherwise, present in sea water.

Effect of Oil Coating on Concrete.—In April, 1914, the Navy Department put into commission fuel-oil pipes adjoining these specimens. Oil spilled on the sea has heavily coated them from near their tops to low tide. The writer believes this coating retards the action by the sea water and, therefore, will lengthen the time required for this test, which, however, will not destroy its value.

At low tide, on May 22, 1922, the writer made an examination of the specimens. No appreciable change could be observed from the condition as described in the 1920 report of the Aberthaw Co., and the order of deterioration was the same as that given by Capt. Bakenhus in his report of 1917.*

Two of the 24 original specimens, Nos. 19 and 21, have been lost; and five are in poor condition and may be considered to have failed. These five, which are Nos. 7, 11, 13, 22, and 23, were made of 1:3:6 concrete. Capt. Bakenhus makes nine classes, or degrees, of failure, placing No. 7 in the worst class, Nos. 22 and 23 next to the worst, that is, in Class 8, Nos. 11 and 13 in Class 6, fair condition.

Specimen No. 7 was mixed dry, whereas the other specimens were mixed wet. Specimens Nos. 1, 4, 8, and 9 show some deterioration. Nos. 1 and 4 are of rich proportions, but mixed dry, whereas, Nos. 8 and 9 are of plastic and wet mixtures, but of lean proportion. The remainder, Nos. 2, 3, 5, 6, 10, 12, 14, 15, 16, 17, 18, 20, and 24 are in fairly good condition.

On May 24, 1922, Specimens Nos. 7, 11, 22 and 23, shown on Fig. 1, were removed for testing. No. 7 was made of three average, normal Portland cements, in equal parts, thoroughly mixed, and then repacked in bags for use in mixing the concrete. No. 11 was made of Blanc (white Portland cement), very wet. No. 22 was made of 90 per cent of the same cement as No. 7 and 10 per cent of hydrated lime, very wet. No. 23 was made of cement like that of No. 7, plus Sylvester solution of soap and alum, very wet.

Condition of Test Specimens.—When the specimens were removed from the water they had, at the tops, about ¼ in. of gummy, sticky adhesion of fuel oil and dirt, which, toward the low-water mark, became thinner with a harder, somewhat glossy surface.

No oil could be noted below the low water-line, but the specimens were coated with live mussels, which indicated that the impurities of the water were chiefly on the surface and were not sufficient to kill marine life.

Some of the specimens had previously been cracked in being removed from the water and some pieces that broke off at the cracks showed a slight brownish discoloration, which indicated that the oil had not penetrated very deeply or in any volume into the cracks. No evidence of penetration of oil below the surface of even the poorest specimens could be detected at fresh fractures of the concrete. Discoloration was not more than 1/32 in. deep. In all these specimens, the parts most damaged, namely, those near mid-tide, showed a rather disintegrated and soft concrete.

The specimens were cut to approximately square faces, the length of the test pieces being more than twice the width of the cross-section. The steel reinforcement was cut off and burned below the surface. The test pieces were then faced to a flat surface resembling terrazzo.

The top end of Specimen No. 7 was so short and so badly cracked that it was impossible to obtain a test piece larger than about 8 by 8 in. by 15½ in. All the others were of the full cross-section and about 3 ft. long.

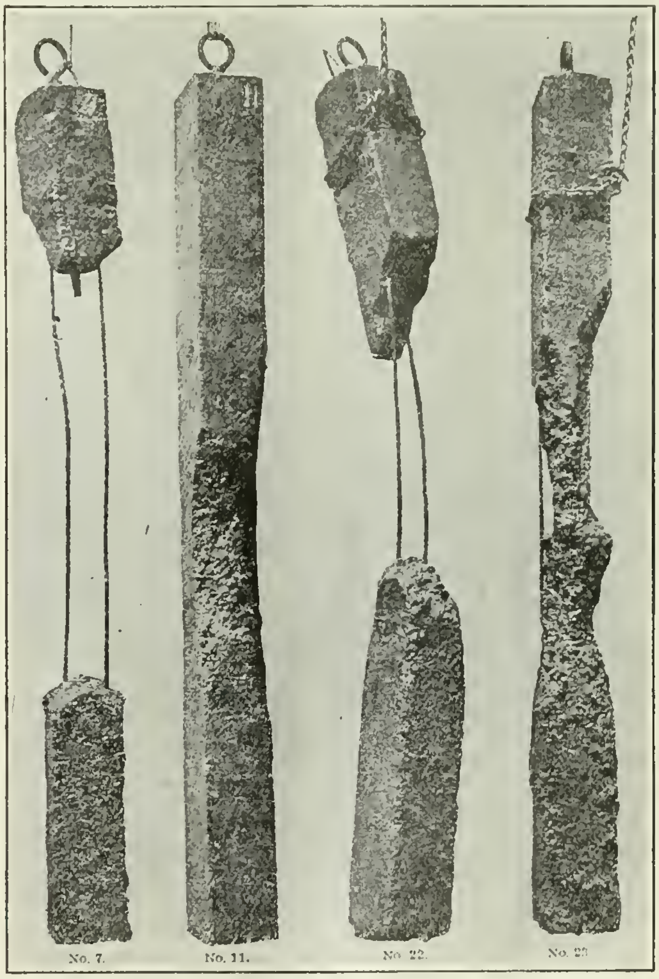


Fig. 1.—Aberthaw Test Specimens.

Bearing Area of Specimens.—Through the courtesy of Prof. H. W. Hayward,, M. Am. Soc. C. E., they were tested at the Massachusetts Institute of Technology on June 7, 1922.

TABLE I.—ACTUAL BEARING AREA OF TEST SPECIMEN.

No. of piece.	Bearing.	Area, in square inches.	Average area, in square inches.
7 Top	Top	51.8	
	Bottom	62.8	57.3
7 Bottom	Top	232	
	Bottom	230	231
11 Top	Top	236	.....
11 Bottom	Top	240	....
22 Top	Top, poor	200	....
	Bottom	215	207.5
22 Bottom	Top	217	
	Bottom	208	212.5
23 Top	Top, fair	213	
	Bottom	238	226.5
23 Bottom	Top	221	
	Bottom	224	222.5

A piece of blotting paper was placed on top of the first specimen and under both ends of the remaining specimens. From the impression made on these sheets, it was possible to obtain the net bearing area and the character of the bearing. The edges of the test pieces were irregular and, on some, the corners were broken so that it would have been difficult to obtain the bearing area by direct measurement. In Table I is given the average bearing area of each end, which area is approximate only, and the writer is convinced that it is too large, rather than too small. The specimens were tested only to the point of failure. Cracks appeared longitudinally, and formed roughly two prisms the shape of an hour-glass. Reinforcing steel that was exposed after the tests, appeared to be bright. Specimen No. 7, the most porous one, was so broken after the test, that the reinforcing bar was removed. With the exception of three spots about ¼ in. in diameter which showed rust, the bar was entirely bright. This bar was from the lower end of the specimen which had been immersed for 13¼ years.

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*Transactions Am. Soc. C. E., Vol. LXXXI (December, 1917), page 645.

For chemical analysis, a sample was taken from the top of the specimens, one from the lower corner of the bottom specimen and one from near the center. Mr. Herbert L. Sherman, a cement chemist, co-operated with the writer in making chemical and physical analyses of the cement in the making of the specimens.

After a careful and complete analysis of three samples each from Specimens Nos. 7 and 23, and a thorough study of the results, Mr. Sherman reports that it is impossible to draw any conclusions.

Results of Crushing Tests.—The result of the crushing test is given in Table II. The original cross-section is copied from the earlier report, and is not a scaling of the specimens at the present time. It will be noted that the normal mixture of concrete shows results as good as could be expected of any concrete of this mixture and age. It will be noted also that the lower end of each of the four specimens was stronger than the upper end.

Omitting Specimen No. 7, from which only a small sample could be tested and which, therefore, may not be directly comparable with its own bottom, the other three show the strength of the top to be about 92 per cent of that of the bottom. This indicates that there is a common law as to the condition of the concrete when permanently wet as compared with dry.

The following summary of tests on 1:3:6 concrete mixed dry, plastic, and wet, on four brands of cement, cured in air for 1.6 to 1.75 years is given for comparison with laboratory specimens. The data on these specimens, which were 12-in. cubes, was taken from the Annual Report of the State Engineer of New York for the fiscal year ending September 30, 1897. Fifty-two specimens were crushed at the Watertown Arsenal, the dry specimens being 9 per cent stronger than those from plastic or wet concrete:

Highest crushing strength per square inch....	2,887 lb.
Lowest crushing strength per square inch....	1,716 lb.
Average crushing strength per square inch....	2,095 lb.

Other Tests of Effect of Sea Water on Concrete.—In 1912, the writer built, in Portland Harbor, a fish pier that consists of a wharf, supported by concrete piers about 4 ft. square, with a heavy floor forming the wharf platform, on which a fish house was built. Most of these piers were built inside a coffer-dam, and, therefore, were cast dry and allowed to set more than a month before being subjected to the tidal action of the sea.

The two rows of piers nearest the shore, being out of water except during high tide and never being immersed more than about 3 ft., were cast between tides. An examination of these piers was made on May 25, 1922, at which time they were ten years old. All the piers cast within the coffer-dam appeared to be in first-class condition, whereas those cast between tides showed some signs of deterioration below high-tide line.

TABLE II.—CRUSHING LOAD ON SEA-WATER TEST SPECIMEN.

No. of piece.	Original cross-section in inches.	Area, in square feet.	Length of test specimen, in inches.	Actual section, in inches.	Total load, in pounds.	Load in square inches, actual section.	Ratio of strength, top to bottom.
7 Top	15⅞ by 16 9/16	1.82	15½	57.3	157,300	2,750	
7 Bottom	15⅞ by 16 9/16	1.82	35½	231	778,800	3,375	0.82
11 Top	16 by 16¾	1.86	36	236	750,200	3,180	
11 Bottom	16 by 16¾	1.86	37	240	823,900	3,435	0.93
22 Top	5⅞ by 16¾	1.80	30¾	207.5	463,100	2,235	
22 Bottom	5⅞ by 16¾	1.80	36	212.5	562,100	2,645	0.92
23 Top	6 3/16 by 16¼	1.82	32½	226.5	391,600	1,730	
23 Bottom	6 3/16 by 16¼	82	33¾	222.5	424,600	1,907	0.91

In 1902, a series of concrete specimens was made in order to test the protection of steel from corrosion. The concrete was of 1:3:6 proportion, with the expectation that it would be porous. The blocks were 4 in. square and 12 in. long, and had a ½-in., square twisted steel bar, 16 in. long, through the center, that projected at both ends.

At Fort Warren, the War Department, immersed one series of these specimens in sea water and, after 3 years' testing, the remainder of this series was lost.

The second series was given to the Chief Engineer of the Metropolitan Sewerage Commission, and were immersed in a trunk sewer. After seven years, the remainder of this series was lost.

The third series of specimens was buried in ground that was always damp and at times was saturated with water. After being twenty years in the ground a specimen from this series was removed and split open. The steel was bright in every specimen of all three series where the cement was in close contact with it; rust was present where there were voids. When the bars were originally embedded, they were coated with hard rust, but no scales. There results indicate that cement will protect steel from corrosion in unfavorable conditions.

Conclusions Drawn from the Tests.—Although it is not time to draw final conclusions from these series of tests, and although the series is not sufficiently comprehensive to prove a general rule for all cases of immersion of concrete in sea water, it is thought that some conclusions are now justified, and ought to be helpful to those designing marine structures.

It appears, first, that the mechanical action of the elements is much more vital than the chemical action. The densest specimens show the least wear. The porous specimens which were built with the expectation that they would soon disintegrate, have done so.

Chemical action must be considered. The specimens in which the cement was low in alumina, both of lean and of rich mixtures, are in good condition. Those that had foreign ingredients (Nos. 22 and 23), of hydrated lime and Sylvester solution, show serious weakness, whereas one specimen containing 5 per cent of clay as filler to make the concrete dense, is still in quite good condition.

The question of the quantity of water used in mixing must be considered. †In a paper by Mr. Dan Patch, photographs are shown of the specimens arranged in three horizontal rows, in the order of the quantity of water used in mixing, and superimposed is a curve showing resistance to compression and to wear as determined by the Research Laboratory of the Lewis Institute of Chicago, Ill. The condition of the specimens shown in these photographs indicates that those containing from 9 to 10 per cent of water are in better physical condition than the very dry or the very wet specimens.

If good workmanship is observed in the placing of concrete in forms, excess of cement and mortar is brought to the surface and produces a skin which, until abrasion has removed it, resists very well the action of sea water. The concrete is not as durable in resisting wear as this skin.

Specimens made of the poorer materials, which fail the earliest in their lower portions, due to tidal action, have proved durable if permanently immersed. An explanation of the reason for the upper end of the specimen showing less strength than the lower end may be due in part to the matter of suspension. In order to handle the specimens readily, ⅝-in. square twisted steel bars were extended about 2 in. from the surface the full length at opposite corners. In the center of the specimen, a hole was cored into which was grouted a hook with a shank about 3 ft. long, by which the specimens were suspended. The weight of the specimen produces a tension of about 100 lb. per lin. in. in the upper 3 ft. This condition may have produced porosity, or invisible cracks, through which weathering took place. The upper end was subjected to yearly variations of temperature of probably 100° F.—sometimes, to changes of many degrees within a few hours—at times to a film of ice on the surface, and to a slight degree of abrasion of floating objects in the water.

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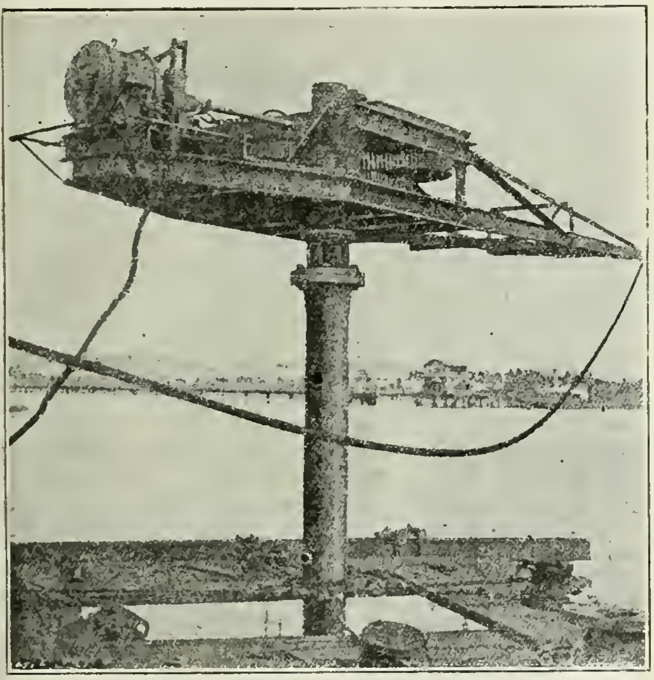
†Engineering News-Record, March 3, 1921.

It seems safe to conclude that if rich concrete is made from a good quality of cement, of normal composition, or low in alumina, and the material is thoroughly mixed, using 9 to 10 per cent of water, and placed in the dry with careful spading to assure a dense surface, that durability in sea water can be assured unless the specimen is subjected to considerable abrasion, in which case it would be wise to face the concrete with a protective coating within the limits of the rise and fall of the tide. Below low tide, and above high tide, concrete as described is a practical, satisfactory, and proper building material.

An English Screw-Pile Driving Machine

A portable machine for putting down screw-piles is described in a recent issue of Engineering, London. The machine consists of a frame built up of channels and angles, etc., mounted and balanced about a heavy steel shaft. The latter is fitted with a flanged coupling piece which bolts directly on to the top of the pile to be driven. The shaft is driven by motor through a worm and worm wheel and intermediate gears, the worm wheel being mounted on a sleeve, on which also a pinion is cut. The latter gears with three larger intermediate gears, which are integral with three small pinions which in turn mesh with a larger spur driving the shaft. The speed of the drive is thus geared down to suit the diameter of the pile, nature of the soil, and so on. Either a gasoline motor or electric drive may be adopted, the machine illustrated being provided with the latter. The weight of the frame is taken on a large ball-bearing resting on a shoulder on the central shaft.



Screw-Pile Driving Machine.

In use, the machine is slung by a crane over the pile, and the flange bolted to the top flange of the pile to be driven. A light cable is carried from the end of the long arm and made fast to a fixed point, on shore or part of the structure already built. Owing to the large radius of this arm, the actual load on this cable during the driving of the pile is comparatively light, and by adopting a light line which will carry away if the load becomes excessive, a very effective safety device is obtained to guard against damage or breakage of the pile, should an obstacle be met with while sinking. In addition to this, a safety device can easily be applied to the driving machine, if thought desirable. In addition to the elimination of heavy bending stresses on the pile, the use of this machine renders the erection of elaborate staging unnecessary. The staging employed need only be sufficient to carry guiding tackle to keep the pile in proper vertical alignment. It is stated that in one contract recently, piles were sunk with this machine at from seven to ten times the rate previously attained in hand driving.

Town Planning in Great Britain

From The Surveyor, London.

The present year should find most surveyors busy town planning, for the preparation of a town-planning scheme before Jan. 1, 1923, is made compulsory on all urban authorities with populations exceeding 20,000. The housing question during the past few years has over-shadowed town planning, and much of the enthusiasm of councillors and officials for town planning has evaporated, or been dissipated by the difficulties attending the preparation of a suitable scheme. The former regulations were very exacting in their procedure, and gave a great amount of unnecessary and wearisome work to town-planning staffs.

Over twelve years have elapsed since the first town-planning act was passed, and which, when it was launched with the vigorous and enthusiastic support of Mr. Burns, promised to be so beneficial. The results have, however, been very disappointing. During these years we have had numerous great conferences on the subject and much spade work has been done in many directions. There can be few municipal engineers or surveyors who have not given much thought to town planning, and the preparation of a scheme for their district. Still, as only about one-tenth of the local authorities in the country have schemes in preparation, and only seven have been approved by the Ministry of Health, there is evidently "something wrong in the State of Denmark."

Local Authorities' Apathy.—It points to great apathy on the part of the local authorities, which will need strong measures on the part of the Government if it is to be dispelled. The subject is so important and fraught with such great possibilities for improving the health and welfare of their district, that one would expect every local authority would be anxious to support a town-planning scheme. That they do not is largely due to the lack of understanding of the great power it puts into their hands. The surveyor, who is generally anxious to see the scheme carried out, has some difficulty in pushing it forward, for he is frequently suspected of having some ulterior and unworthy motive for doing so. Where there are a large number of councillors it is difficult to avoid treading on someone's corns, and the slightest interference with vested interests is likely to lead the official into trouble.

Still, the loss experienced by most towns through not preparing a town plan is so great that it only requires bringing forward in a clear and forcible manner to transform this apathy into enthusiasm. A scheme which will give the council power to lay out its arterial roads well ahead of immediate requirements, fix building lines so that future widening of the road may be carried out economically, locate the industries of the district in positions where they can be developed cheaply and with little nuisance, reserve suitable land for residential purposes, limit the number of houses per acre, determine shopping and civic areas, and provide suitable recreation grounds and other amenities, cannot but appeal to them, and only needs bringing home with sufficient force to arouse the average councillor from his apathy and awaken his enthusiasm for the important work before him.

Another thing that is wanted is the banishment of the small jealousies which keep various local authorities so often at arm's length. Schemes that should be passed for the benefit of both districts are frequently wrecked by unworthy suspicions and for want of a little common sense and trust in each other.

There are other councils who merely look upon a town-planning scheme as a means for increasing the surveyor's staff, a matter which, in these days, is a sufficient objection to damn any proposal he may bring forward. In many cases the overworked surveyor, knowing he cannot obtain any assistance in the preparation of a town-planning scheme, simply lets the matter slide as the least difficult manner of dealing with it.

It is up to the municipal engineers and surveyors of the country to get rid of this apathy and throw themselves into the work with enthusiasm. Speaking at the annual meeting of the Institution of Municipal and County Engineers in June last, Mr. Gibbon, assistant secretary of the Ministry of Health, said that "the future of town planning in this country depended more on the municipal engineer than on any other class of men."

In a paper read at the same meeting, Mr. L. Leeper said there were 238 schemes in course of preparation, but only seven had been completed in all their stages. In a return published in 1916, Mr. Cockrill showed that 82 per cent of the schemes then in preparation were being prepared by municipal engineers. There is no reason to think that this percentage is less today, and it shows conclusively that the bulk of the work must fall on the municipal official. Despite this it will be very necessary during the present year to be prepared for a renewal of the claim of the architectural profession to prepare these schemes. Fortunately, public bodies have got somewhat tired of their grandiose schemes, and they prefer a less ambitious scheme that they can understand and afford to carry out to one which promises them a new Eden, but which is more likely to prove "a castle in Spain."

Commonsense Planning.—Idealism is necessary in most things, but it must be allied with common sense if it is to be brought within the range of practical politics. Some of the schemes that have been put forward by architects show very little consideration for expense; but, as Mr. Gibbon remarked, "in the future town planning is going to be judged strictly and sternly at the bar of economy. There was no sphere of local activity which opened up the possibility of so rich a return, not only in the avoidance of waste, but in the production of good, as town planning. Much of the waste which was taking place today was due to the lack of foresight in the planning of towns in the days of old."

How far the great growth of motor vehicular traffic and the schemes for supplying electricity in bulk from large power stations will affect town planning is a matter for serious consideration. Social and industrial problems are looming which may radically alter the outlook. Will the growth of our large towns continue, or shall we see an exodus of town populations to the country? Man is a gregarious animal, and has herded in large or small communities in all ages, and for most men the town has an attraction which the charms of the country fail to counteract. Among the attractions on which he places most value are the better sanitation and water supply, the well-planned and lighted streets, the educational facilities, the opportunities for amusement, and the wider field for making a living. The motor 'bus and the motor car are, however, going to play a great part in abolishing the dullness and isolation of the village and country house. We hear today of projects for travelling theaters, in which artists, scenery and theater are to be moved from village to village by motor transport. The shops of the large town are now as easy of access as the village shop, and the last 'bus carries the village patron of the cinema and music hall home with regularity and in comfort.

How far the supply of electricity in bulk is going to alter the conditions of life in our villages it is perhaps too early to say, but that it will materially alter their character in many cases there can be little doubt. Cheap land for factories and housing, with cheaper living by the cultivation of a large kitchen garden, will largely help that trek to the country which we have seen so many large industrial firms make in the past few years. With plentiful and cheap motor haulage many firms are independent of the railway; and lower rents and rates are points which help to tip the beam when the advantages of town or country are being put into the scales.

Many town workers will be glad to exchange the noise and smoke of the town for the quiet and purer air of the country, and these will no doubt jump at the opportunity of doing so afforded by the better transport facilities now offered. On the other hand, the "garden suburb" lost a good deal of its popularity during the war, and the period since, which subjected them to the inadequate and infrequent services caused by the coal and railway strikes. Many dwellers in these districts gave up their houses to go into flats or houses in the town. Still these dormitory districts of our great towns will, with better and safer transport, probably get a new lease of life. The growth of the "garden-city" type of community, typified by Letchworth, in which men not only sleep but make their living, has not been so rapid as its admirers expected, despite its many advantages and attractions.

New Problems.—New problems appear to be arising from the growth of great industries on the fringe of our large towns, where the workers engaged outside the town are to a large extent housed in the town. A town like Doncaster, which is ringed with important collieries, is likely to develop as a large residential town, for the miners and other industrial workers prefer to live in the town where they and their families can enjoy the social, educational and civic amenities which a large town provides.

Housing and town planning have a close connection, and though the natural course would be for a town-planning scheme to precede a housing scheme, yet during the past few years the procedure has been reversed. Housing is certainly one of the most important features of a town-planning scheme; but it is only one part of the scheme, and besides the question of communications, the location of the various areas for industry, residence, civic life or amenities, there is the difficulty which has to be met in the case of "zoning." The production of a comprehensive scheme which will embrace a number of districts having a community of interests is a matter of great difficulty, but that it is necessary in many parts of the country is undoubted. In thickly-populated districts boundaries are sometimes definitely and awkwardly shown by the junction of a fine wide road in one district with a narrow and neglected road in the next. It has been said that it is impossible, or municipally immoral, for one town to plan for itself without consulting its neighbors. This has been the experience of many large towns, and the power to plan for the districts adjoining is necessary if an efficient town-planning scheme is to be prepared. It has been claimed that anything short of dealing with the whole of an industrial area, such as we get in Yorkshire, Lancashire, and the Midlands, is not town planning, but site planning, and it is necessary for all concerned to come into conference if a plan worthy of the district is to be prepared.

New Town-Planning Regulations.—Revised regulations for the preparation of town-planning schemes came into operation on May 2nd last year. They supersede the previous regulations, simplify the preparation of schemes, and avoid the sterilization of land during the time a scheme is being prepared, which has previously been a serious difficulty and hindrance to development.

The need for avoiding the waste of haphazard growth of towns is pointed out in a circular issued by the Ministry of Health, and the gains of industry by proper planning of the district in the location of factories, work shops and businesses in the places best suited for them, and by providing proper roads and other communications is emphasized.

On January 1, 1923, town planning becomes compulsory in all boroughs and urban districts with a population exceeding 20,000. Local authorities are advised at the outset to make their town-planning schemes as simple as possible, concentrating on the two essentials of settling the principal lines of communication and allocating areas for the purposes for which they are best suited (zoning), whether industrial, business, residential, or as open spaces. In order to save time and expense the Ministry have framed new regulations which provide for the preparation of a town-planning scheme in three stages—the resolution to prepare, the preliminary statement, the scheme. Local authorities may merge the two former or the two latter if they are in a position to do so. Maps must be Ordnance maps, and copies sent to the Ministry must be folded in book form. 1-2500 maps will generally be required, but 6-in. maps will be accepted for maps 1 and 2 where the required particulars can be shown with sufficient accuracy. The district valuers will supply the names and owners of the land included in the authority's scheme if they possess the information. The Ministry are of opinion that it is desirable that there should be one town-planning scheme for the whole of an area forming one economic unit. If there is more than one local authority in this unit they should confer and co-operate in preparing a scheme.

Strength of Concrete Stoppings in Coal Mines.—For the purpose of determining specifications for the construction of concrete stoppings in coal mines that may be developed on the public lands of the United States, the Bureau of Mines, in co-operation with the Bureau of Standards, is constructing in the experimental mine at Bruceton, Pa., a chamber in which it is proposed to conduct tests to determine the strength of reinforced concrete stoppings when subjected to a pressure, up to 50 lb. per square inch, suddenly applied. The tests require the construction of a permanent stopping, which was completed at the close of the fiscal year, and a test stopping, which is under construction in accordance with a design prepared by the Bureau of Standards. The work is under the personal direction of J. W. Paul, chief coal mining engineer, assisted by H. C. Howarth.

Method and Cost of Building Reinforced Concrete Shaft Houses

Two reinforced concrete shaft houses having a number of interesting design and construction features were constructed in 1919 at the Cliffs shaft mine of the Cleveland Cliffs Iron Co. at Ishpeming, Mich. The following particulars of this work are abstracted from a paper by J. Ellzey Hayden and Lucien Eaton, in the 1921 Transactions of the American Institute Mining and Metallurgical Engineers.

When the proposition was submitted to W. G. Mather, president of the company, he recommended that, on account of the prominence of the buildings due to their location, an effort should be made to combine in the design as far as practicable something of architectural beauty. Following his recommendations, the original plans were submitted to the Condron Co., structural engineers, of Chicago, Ill., with George W. Maher, also of Chicago, as consulting architect. Three designs were submitted by them, of which that shown in Fig. 1 was chosen.

General Features.—The two shaft houses are not exactly the same in design, being right and left hand and differing in several minor details; the plan and elevation of the A shaft house are shown in Fig. 2. The design calls for a reinforced-concrete building 33 ft. square inside at ground level, with solid vertical walls for 31 ft., then tapering to 21 ft. square at the eaves at a height of 88 ft. 9 in., with a pyramidal roof. The extreme height is 96 ft. 9 in. above the footings. Except where additional sheds have been built outside, there are 14 windows on each side, and there are three doors. The three floors above the ground are connected by a ladderway. The pockets, built in 1910, in the old shaft houses were retained unchanged, and openings for them were left in the sides of the new shaft houses.

The shape and size of the new shaft houses had to be such that all new construction work would be clear of the old shaft houses, and the positions of beams and floors were governed largely by the available openings between timbers on the old shaft houses, as it was impossible to cut through any of these timbers. The beams for carrying the sheaves were heavily reinforced and made strong enough to carry a load that would break the hoisting rope. Extra reinforcing was put in the walls under these beams. The beams for the floors were designed for a safe load of 200 lb. per square foot, and the floors were made of 3-in. plank. The guides for the skip and cage are carried on vertical 12 by 12-in. fir timbers, which are securely fastened to the concrete beams.

Work on the new shaft houses was started on July 21. 1919, both houses being built at the same time. The A shaft house was completed on Dec. 6, and required 725 cu. yd. of concrete; the B shaft house was completed on Dec. 11 and required 1,014 cu. yd. of concrete. The work of tearing down the inside forms at both shaft houses was commenced soon after. A total of 132 working days was required for the work; 55 working days were required for pouring concrete and 77 working days for building forms and reinforcing. The maximum amount of concrete poured in any day was 52 cu. yd.

Handling Concrete Aggregate.—The gravel for the work was obtained from a pit 200 ft. west of B shaft, where a bin was constructed, with a chute to feed the mixer for the B shaft house and a side chute for loading into wagons for transportation to the A shaft house. All gravel for the latter was hauled by teams. A 1¼-yd. gravel car, hauled up an inclined track by an air-driven hoist, carried the gravel from the pit to the top of the bin, where it was passed over a 1¼-in. grizzly, all oversize being raked off and wasted. From this bin the gravel for the B shaft house was drawn off into a measuring box, which was tilted into the mixer by an Ingersoll-Rand Little Tugger hoist. The ½-yd. air-driven mixer was set below this measuring box and the concrete was drawn off into ½-yd. buckets which were set on low trucks and trammed on a narrow-gage track to a skidway up the shaft house. At the A shaft an inclined platform was constructed and the gravel wheeled in barrows to a 1-yd. mixer. A narrow-gage track carried the bucket to the skidway at the shaft house, as at B shaft. At both shafts air-driven hoists installed on the second floor of the old shaft houses were used to raise the concrete to the hoppers, from which it was run through wooden chutes to the forms. These hoppers were raised as the work progressed. In order to prevent separation of the aggregate, the vertical drop of the concrete into the forms was kept as low as possible, being seldom more than 6 ft.

At B shaft, the skidway was built outside the forms for the concrete shaft house, the upper end only being braced on the old building. When the top of the old shaft house was reached, a temporary framework of 6 by 8-in. timbers was built 30 ft. higher and the skidway was connected to this. The legs that extended beyond the new roof were cut off when the concrete had been poured high enough in the forms. At A shaft, the skidway was built outside the old shaft house and inside the new one, and was carried up on a temporary framework to the roof of the new building. The concrete for the top part of the roof was dumped into a box and hoisted through a trapdoor in the roof by means of a 14-qt. bucket. This hoisting was done by hand but less than 15 cu. yd. of concrete was thus handled.

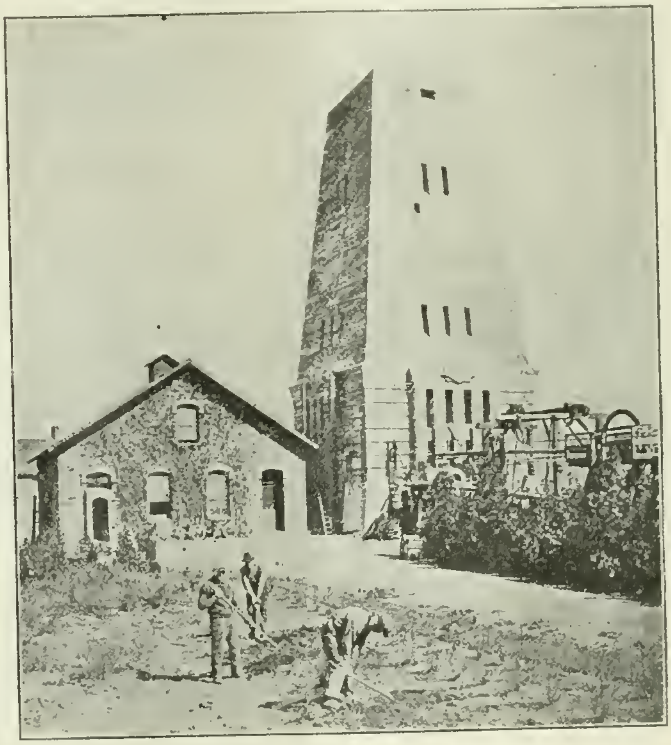


Fig. 1.—The Completed A Shaft House.

The Footings.—The ground around A shaft was hard and compact and offered no difficulty in placing the footings, which were put in to a depth of 3 ft. Two courses of 25-lb. rail were placed in the footings, the bottom course of five rails, and the top course of three rails. A total of 119 cu. yd. of concrete mixed 1 to 5 was used in these footings. At B shaft, considerable difficulty was encountered in placing the footings. The old shaft had been put down through 60 ft.

TABLE I—COST OF ERECTING TWO CONCRETE SHAFT HOUSES AT THE CLIFFS SHAFT MINE, ISHPEMING, MICH.

	Total		Per Yard		
Concrete:	Labor.	Supplies.	Labor.	Supplies.	Total.
Stripping gravel pit..	$ 273.84	$ 334.68	$ 0.158	$ 0.192	$ 0.350
Loading and hauling gravel	2,584.30	582.83	1.486	0.335	1.821
Cement	516.80	5,065.31	0.297	2.913	3.210
Forms, erecting and tearing down	13,411.99	7,185.71	7.712	4.132	11.844
Excavation and grading	511.93	112.55	0.295	0.064	0.359
Mixing and placing	4,821.05	743.92	2.772	0.428	3.200
Dressing surface	49.45	....	0.028	....	0.028
Special tools	12.79	20.30	0.007	0.012	0.019
Preliminary construction	2,225.14	404.26	1.279	0.233	1.512
Reinforcing	4,924 83	3,401.51	2.833	1.956	4.789
Total	$29,332.12	$17,851.07	$16.867	$10.265	$27.132
Sheaves, floors, and runners	$ 3,250.90	$ 1,040.77	$ 1.869	$ 0.599	$ 2.468
Lighting and heating.	246.11	169.61	0.141	0.098	0.239
Tearing down old shaft houses	762.59	19.51	0.439	0.011	0.450
Moving tracks and chutes	620.34	8.01	0.356	0.005	0.361
Office, supervision, and consulting engineer.	....	3,242.45	......	1.865	1.865
Total	$34,212.06	$22,331.42	$19.672	$12.843	$32.515

of quicksand, which had formed a crater around the shaft during sinking, and this crater had been filled with rock, which was loose and full of voids. It was therefore necessary to go down to a maximum depth of 26 ft. to obtain a secure base for the footings. The ground under the old shaft house and around the shaft was then treated to a wet mixture of concrete, which closed the voids in the old rock fill. Three courses of 25-lb. scrap rail were placed in these footings, five rails in the bottom course, four in the middle, and three in the top course. Vertical rails were also set into the footings to tie them to the shaft house proper. A total of 339 cu. yd. of concrete was put in for the footings of this shaft house.

The Forms and Reinforcing.—The lumber used for the forms was as follows: 2 by 6-in. hemlock studs were used throughout and were placed 16 in. between centers. For the first 10 ft. above the footings, 2-in. rough hemlock plank was used, but above this 1-in. hemlock, dressed on one side, was used; the change from rough to dressed lumber was made for the architectural effect. The lumber was given a coat of paraffine oil before being placed in the forms.

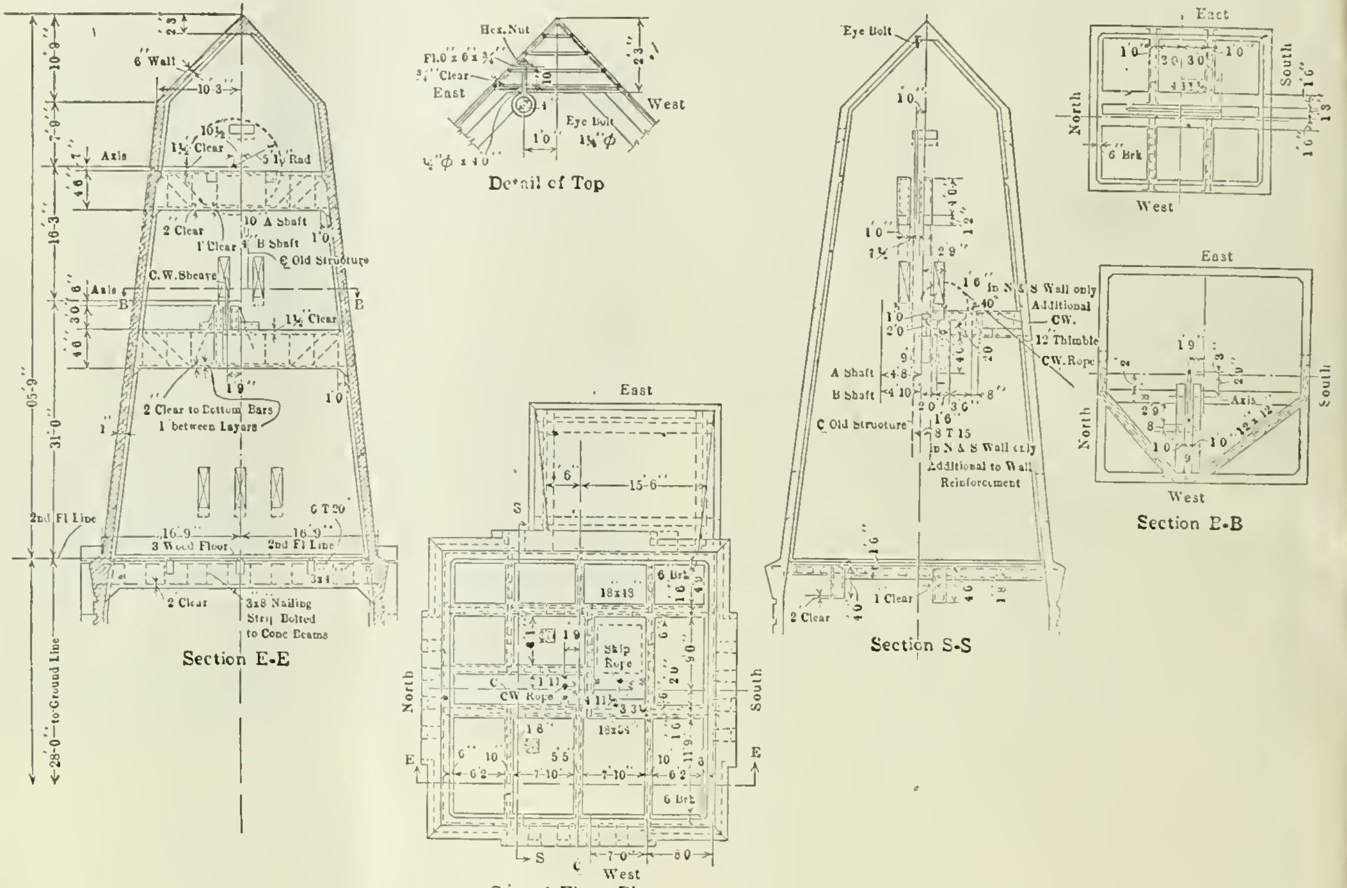


Fig. 2.—Plan and Elevation of A Shaft House.

No. 9 annealed iron wire was used throughout in holding the forms. It was placed on every studdle at intervals of 2 ft. in elevation. Patented "EZ" clamps were used to draw up the wire and hold the forms to correct dimensions. Deformed steel ½ in. square was used throughout for the reinforcing, except over the doors and in the beams, where 1⅛-in. square twisted steel was employed. The reinforcing was tied together and held in place with 6-in. wire ties. Patented auger twisters were used to tighten these tie-wires. Huron Portland cement was used throughout the work, a 1 to 5 mixture being used in the footings, and a 1 to 4 mixture in the shaft house proper.

The shaft houses were built and poured in sections, varying from 6 ft. to 16 ft. in height. While the forms at one shaft were being filled, those at the other were being extended. On the entire job, hoisting in the shafts was interfered with only once; that was for 4 hours one Saturday night when it was necessary to stop the skip while the beams in the A shaft were being poured.

The many architectural features of the design, together with the fact that it was impossible to brace the new construction on to the old shaft houses, on account of their constant vibration during hoisting, made the work of form building difficult and slow. To help hold the forms to correct dimensions during construction, concrete block spreaders were used at 6-ft intervals. These spreaders, together with the "EZ" clamps, permitted the tightening of the form wires so that all heaving of the forms during the pouring was eliminated. Great care had to be exercised in the distribution of the concrete into the forms, to prevent the weight from coming unevenly on the forms and pushing them out of line.

Concerting Operations.—At first the pouring of concrete was done on both the day and the night shifts, in order to reduce to a minimum the number of lines in the walls. When cold weather set in, the height of the pour was reduced to such an amount as could be successfully completed on the day shift. At each pour the top surface of the concrete was mauled and roughened up, all refuse was blown off by a compressed-air blast, and before the new pour was commenced the top surface was washed with a mixture of cement and water. Also, when cold weather set in, each mixer was provided with a Hauck kerosene blower, which delivered a hot flame into the aggregate as it was being mixed, so that the concrete was delivered into the forms at a temperature of about 80° F. Large canvas tarpaulins were hung 8 in. away from the form line, on the outside of the shaft, to reduce radiation over the section to be poured, and burlap bags were used for covering the top surface of the completed pour.

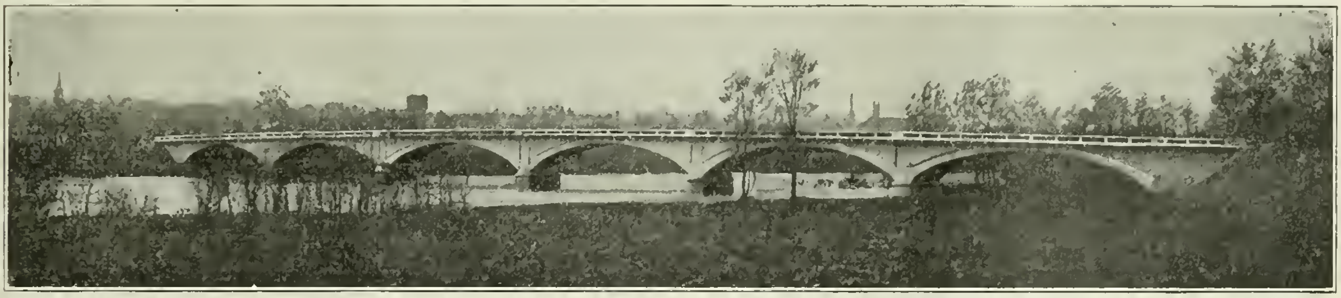
The very cold weather that existed throughout the last three weeks of the work necessitated further precautions against freezing. Steam radiators were installed on the inside near the top of each shaft house; the outside forms were packed with straw between studdles; and a second line of boards was put on. In addition to this, tarpaulins were hung on the outside. When the thermometer was at zero, the concrete 24 hours after pouring was warm to the touch.

The crew employed consisted of 15 carpenters, including one boss carpenter; nine reinforcing men, divided into three gangs of three men each; and two puffer men; in addition, 24 men were used only when pouring was being done. A blacksmith and helper were used part of the time for cutting and bending bars. The job was carried to completion without a serious accident, only a few minor cuts and bruises being sustained. The monograms placed on the panels near the cornice were cast separately in a mold, and were put in place after the rest of the building was completed.

Table I shows the distribution of costs.

Fountain County's Bridge Over the Wabash River at Attica, Indiana

Three outstanding features mark with special interest the new bridge over the Wabash River, between Fountain and Warren counties, Indiana. The financing of a project of this character by a single county, the speed with which the undertaking was accomplished once it was decided upon, and the artistic merit of the structure. Details of the engineering design, the construction and other matters are omitted here because they possess less novelty—not because they are less creditable than other features.



The New Bridge at Attica, Ind.

Initial Consideration.—The first bridge at this location was a toll bridge built by private interests in 1860, and destroyed by a cyclone in 1886. Its contract cost was: Superstructure, $12,000; masonry, $8,160; total, $20,160. This original structure was replaced by an iron bridge which is now superseded by the concrete spans shown in the illustration below. Not only had the concentration of modern traffic quite outgrown the old bridge, but the structure had actually deteriorated to a point where it was obvious that it would have to be condemned at a not distant date.

At a meeting of leading citizens of Attica in the summer of 1919 it was decided that a new bridge must be sought, and that the project should be pushed. It developed that the road, of which this bridge was a link, was to be made a State road, but that the State was not prepared to stand the cost of the bridge; and, furthermore, that the county would be without power to build the bridge after the road had passed to the State. These circumstances made haste indispensable.

Financing.—Warren County, across the river, was invited to participate with Fountain County in the project, but after a meeting between the commissioners of both counties, the Warren representatives decided not to join. This placed the entire burden of financing upon Fountain County, but even so, it was decided to see the project through, and the necessary taxpayers' petition was completed Jan. 24, 1920.

The necessity for quick action had led county officials to undertake engineering and other preliminaries before the formal authorization of the project was complete. It was considered that the work could best be carried on under the direction of the State Highway Department, the services of which were accordingly secured, the county paying their cost.

The Highway Department began its surveys on Nov. 3, 1919. Test borings for foundations were unnecessary because the character of the ground was well known. By Dec. 1, detailed plans, estimates and specifications were finished.

On Feb. 9, 1920, the County Council appropriated $282,741, the exact amount of the estimate, and on Feb. 10 the contract for construction was let to the firm of Standish & Allan of Chicago, on a unit price basis totaling $272,540.30. The State of Indiana contributed $19,108 to cover bond discount not originally provided for; and the contractors gave $3,500 to aid in selling the bonds.

War Department and Congressional Approval.—The Wabash River at Attica is rated as a navigable stream by the War Department, although local citizens claim that it has not been navigable since 1832. An attempt to secure approval of the bridge from War Department officials at Louisville failed, and the matter was accordingly taken up at Washington. Authorization for the bridge was signed by the Chief Engineer of the Department on March 1, and by the Secretary of War on March 3. This, it will be appreciated, came only as a result of prompt and energetic action by Fountain County officials.

A more serious problem was presented by the fact that because the Wabash River is in part an interstate stream, an act of Congress approving the construction was necessary in addition to the other authorization. The act was secured by the close co-operative efforts of County, State and Federal officials. The bill was passed by the House on Jan. 19, 1920; by the Senate on Jan. 26, and was signed by the President on Feb. 3.

Artistic Merit of the Structure.—The beauty of the Attica bridge lies in its form—not in superficial ornamentation, and is so completely apparent in the picture that little need be said regarding it. Each part has that highest type of beauty—the visible expression of its actual functions. The proportions of the arches are most pleasing; while such less important features as pilasters, railing, and pier coping details have all been adapted to an harmonious design of the whole structure. A 5-light candelabrum is located at each side of each pier and abutment.

Engineering Cost and Data.—The total cost of engineering, inspection and testing was about $7,000, or 2½ per cent of the construction cost—a low rate under any circumstances, and conspicuously low in view of the requirement of great speed with the initial part of the work.

The length of the bridge is 987 ft. Concrete, exclusive of that in the railings totaled 8,100 cu. yd. Reinforcing steel totaled 236 tons. Foundations are on a bed of cemented gravel 13 ft. below low water, but are further supported by 20-ft. piles, 117 of which were used. The arch spans vary from 130 ft. to 150 ft. clear. The spandrels are all gravel-filled, the filling being consolidated under traffic and weather prior to the paving of the surface. The interior surface is all waterproofed and 4-in. cast iron drain pipes are provided at the piers. Spandrel filling totaled 5,300 cu. yd., while the fill at the west approach contains 13,000 cu. yd.

Work was begun in August, 1920, the delay being due to difficulties in selling the bonds. High water prevented much progress prior to May, 1921.

The new bridge was located about 50 ft. north of the older one with resulting advantage of shortened span and improved alignment of approaches. That the length of the new bridge is greater than the length of the old one is due to the fact that a substantially greater river opening was provided for flood conditions.

William J. Titus, Bridge Engineer of the Indiana Highway Department, personally directed the design and the preliminary work. H. A. Hanapel, also of the Highway Department, was Resident Engineer on Construction. Alexander Cross was superintendent for the contractors.

We are indebted for the foregoing information to Mr. Titus and to The Attica Ledger and Tribune. We are also indebted to the paper named for the photograph reproduced herewith

Methods of Constructing Substructure of Piscataqua Bridge

In November, 1920, contracts were let for the construction of a highway bridge over the Piscataqua River between Portsmouth, N. H., and Kittery, Me. The sum of $1,500,000 was available for the work. Unusually difficult problems were encountered in building the sub-structure. An interesting description of these problems and their solution was given by J. W. Rollins, Jr., President Holbrook, Cabot & Rollins Corp., Boston, the contractor for the substructure, in a paper presented June 21 at the annual convention of the American Society of Civil Engineers. The notes following are taken from Mr. Rollins' paper:

General Features.—The Piscataqua River is not very long, but has great possibilities for trouble. The tidal flow through the 900-ft. channel at Portsmouth is very great, the ebb tide having at times a velocity of 8 miles per hour. Owing to the contour of the channel, the flood tide is on the Kittery side of the river, and the ebb tide on the Portsmouth side. These tides, acting in different channels, form great eddies the force of which cannot be estimated. The normal rise and fall of the tide is 9 ft., and this may be greatly affected by heavy winds.

The river bottom is covered with a layer of cobblestones and gravel under which is a stratum of soft clay or mud, 3 to 10 ft. thick; next, there is a layer of hardpan from 6 to 10 ft. thick, overlying rock. The hardpan is so dense that a 5-ton orange-peel bucket would not touch it, and in the excavation in caissons it had to be loosened with pneumatic hammers.

The borings for the piers and abutments were made with drills, by washborings, and with well drills, the latter being used for the final determination on the piers. The borings and soundings for the Portsmouth Abutment and the North Pier were close to actual conditions as determined by excavation, the North Pier being on rock at Elevation — 80.

The great problem on this job was the moorings and anchors. No information as to the force of tides or water could be found, so the opinion of shipbuilders was obtained. The result of these inquiries was that a force of 80 tons might result from the worst tidal condition. No anchors would hold against such a force; therefore, for the main up-stream and down-stream anchors, cribs about 20 ft. square and 15 ft. high were built and filled with gravel.

The cables used were of galvanized plow steel, 2½ in. in diameter, having a breaking strength of 200 tons. For the side anchors, two 40-ft. concrete piles, weighing 10 tons each, were used, with 1½-in. steel cables. Each anchor had two cables to the caisson, one fastened to the concrete air caisson, the other at the top of the first set of caisson sides, making a total of twelve cables.

The Caissons.—The general design of the caisson was a concrete air chamber, 27 by 75 ft., with a 7-ft. clearance. The walls were 5 ft. above the deck of chamber, and, above that, regular wooden caisson side construction was used. The caissons were built on shore, where the launching space was very narrow and the water only 9 ft. deep at low tide. The launchways were placed on a grade of 2 in. to 1 ft., and it was planned to launch the caisson sidewise.

As no one seemed to know how the caisson would behave if it was launched with the 7-ft. air chamber open, it was decided to plank it solid across the bottom. No special provision for water-tightness was made, except to use matched planking.

The launchway had four double lines of 12 by 12-in. hard pine timbers as fixed ways, with a double set of 12 by 12-in. hard pine timbers as sliding ways. The fixed ways were spaced 4 in. apart and the movable ways had a 4-in. guide bolted between them, thus forming a fixed guide to keep the caisson straight. The fixed and movable ways were bolted together with 4 by 12-in. splices on the inshore end. The caisson was launched by cutting these 4 by 12-in. strips.

The concrete air chambers were designed as the foundations of the piers, and on account of the great depth of the water, the relation between the mass of masonry in the pier and the cubic area of the caisson, was very close. For this reason, it was not considered safe to build the piers solid above the roof of the air chamber designed to carry the hydrostatic pressure to the full depth of water at the pier site. Consequently, the piers were built with side-walls 5 ft. thick at the bottom and 3 ft. thick at Elevation — 80, with three lateral cross-walls and one longitudinal wall in the center. Excessive pressure on the caisson sides was avoided with this distribution of concrete. This form of construction later proved to be a great aid in sinking the caissons. After some experimenting, the caissons were built to their full height, 66 ft. above the concrete. They were loaded to draw 40 ft. of water before being towed to the bridge site.

Work at the North Pier.—It was decided to build the North Pier first, owing to its more favorable position as to depth of water and tidal current. As this pier, the ledge was at Elevation ± 25 at the high corner and Elevation + 18 at the low corner, and was overlaid by 8 to 12 ft. of clay, with some hardpan. This overburden was dredged to the hardpan, about 3 ft. above the ledge. The caisson for this pier was built with one set of caisson sides, 22 ft. above the concrete air chamber. It was loaded to draw about 25 ft. of water and towed to the site.

The northerly side anchors were on the ledge of Badgers Island, whereas all the others were crib or concrete anchors in the river. The flood tide struck the caisson about at right angles to its down-stream northerly side. No great strain was anticipated for the side anchors, as the ebb tide apparently was clear of the caisson. However, it was soon noted that the direction and force of the ebb tide had to be considered. The caisson would rest peacefully for a long time, and then some great swirl or eddy would strike it, and send it inshore, dragging the 40-ton anchors on the river side. With the outside line slacked, the flood tide would send the caisson back, bringing up hard on the inshore cables fastened to the ledge.

With 2,000 tons moving and "bringing up" hard on the inshore cables, it was evident that something must give way, as the side cables were not fastened to the caisson in a manner to withstand these shocks. The caisson, therefore, was taken back to the wharf and another set of sides 22 ft. high were built. A second set of fastenings was also built in it, and a second trip to the site was made.

The second attempt to land the caisson brought the same troubles as the first. The eddies on the ebb tide carried away the outboard anchors, moving the caisson 50 ft. inshore and landing it on the bottom of the river. It was finally decided that the bottom of the river was the only safe place for it.

With a hollow caisson, it was possible to flood the pockets with water and keep it on the bottom, and then, at low tide, pump out the water in one pocket and place the concrete. When a greater depth of water was needed to float the caisson, it was moved at high tide out into the deeper water. When the walls were built to Elevation 80, and concrete sufficient to hold the caisson in its true position on the bottom had been placed, it was moved out at high tide, and then sunk by filling the pockets with water. On the following slack tide, all the lines were "hitched up" and, at the next high tide, the caisson was floated by pumping out the water, lined up, and sunk again in its true position, which was within three in. of the line. Afterward, the caisson was kept on the bottom and sunk to rock.

Construction of Abutments and South Pier.—The Portsmouth Abutment was built at the same time as the North Pier. A pier design was substituted for the Kittery Abutment. It looked simple on the plan—a sloping foundation on rock at an angle of about 30°, the front edge being shown at Elevation 74. Steel sheeting was driven below Elevation 74, 5 ft. in front of the line of the foundation, and the excavation was begun. Trouble soon developed, as the rock "dropped off" almost perpendicularly in the middle of the coffer-dam.

The sheeting was undermined and then driven down to low water. The excavation was made with a bucket, a sand-pump, and divers. The ledge was finally cleaned over the greater part of the area. Concrete was deposited under water, the entire excavation being filled to the sheeting. The excavation having been sealed, the coffer-dam was unwatered after a supplementary wooden dam had been built from the steel sheeting. The masonry was finished after a delay of several weeks.

At the South Pier, the bottom of the river sloped from about 1 ft. to 8 ft., and the rock, according to the soundings and borings, was at Elevations 29 and 26 on the inshore side, and Elevations 23.7 and 19.8 on the outer side. It was intended, therefore, to land the caisson on rock at about Elevation 25. Meanwhile, all the soft material possible had been dredged and the site of the pier had been leveled at about Elevation 30; this meant that inside would be hardpan and outside the original bottom, that is, soft material.

It was feared that the caisson, when landed, would either go out of level toward the river, or would slide out of position into the river. To avoid this, a window of crushed stone, about 3 ft. wide and 2 ft. higher than the hardpan bottom on the inside, was deposited along the outside edge. The caisson was towed to its site and sunk very near to position. On the next high tide, it was floated and pulled into a position 1 ft. inside of its true line. Within 24 hours after it had been landed, it had slid about 12 in. out into the river. It was again floated and placed 24 in. inshore and landed. It again moved about 12 in. and stopped. Rip-rap weighing 1,000 tons was then piled on the outside and no further movement took place. The water was pumped out and the concrete put in. The caisson was permanently landed about 8 in. out of position inshore.

The crushed stone kept the caisson about 1 ft. out of level inshore, until it was landed on hard bottom. At Elevation 26, the supposed rock level, no rock appeared. The sinking was continued to Elevation 20, and still no rock. The sides of the caisson were not high enough, and the shafting, locks, air and other pipes were too short, all of which had to be built up.

The contract did not require excavation to rock, and it was contended that at Elevation 20, the foundation on hardpan was suitable. The caisson was then 19 ft. below the original bottom on the up-stream end, and 12 ft. on the downstream end.

The excavation was continued, and the cutting edge sunk to Elevation 16, 10 ft. below the designed level. The rock was cleared off in places to Elevation 9. As this additional work was done under an air pressure of 40 lb., the cost was excessive, being about $3,000 per foot. However, the entire contract was finished in March, 1922, seven months ahead of contract requirements.

Suspended Ceiling Specifications

After much research in connection with the common practice in the different localities throughout the United States, the following specifications have been approved by the Associated Metal Lath Manufacturers as being the minimum safe specifications for suspended ceilings:

Hanger—The vertical member which carries the steel framework.

The minimum size for hangers shall be No. 8 galvanized wire 13/16-in. flats or 7/32-in. round mild steel rods. The wire is to be attached by twisting three times—flats attached by bolting with ⅜-in. bolts—rods by twisting twice, or by right angle bends and wiring. They shall be spaced not to exceed 4 ft. centers in either direction.

Runner Channel—The heaviest horizontal member.

Runner channels are to be not less than 1½-in. channels with a minimum of .442 lb. per lineal foot. They shall be spaced not to exceed 4 ft. on centers.

Furring Channel—The smallest horizontal member, to which the lath is attached.

Furring channels shall be not less than ¾-in. channels with a minimum weight of .276 lb. per lineal foot, attached to runner channels by at least three loops of No. 16 galvanized wire at each crossing. They shall be set on various centers, depending upon the lath to be used. A maximum of 11¾ in. centers shall be used for 3 lb. flat lath, 15¾ in. centers maximum for 3.4 lb. flat lath, 19 in. centers maximum for 3 lb. rib lath.

Metal Lath—The plastering base and reinforcement.

Metal lath shall weigh not less than 3 lb. per square yard. Metal lath shall be attached to the furring channels by No. 18 gauge annealed galvanized lather's wire, every 6 in. along the furring channels.

Paint Specifications.—The publications of the U. S. Bureau of Standards released during August include the following U. S. Government specifications: C 87, specification for zinc oxide (2d ed.); C 89, specification for white paint and tinted paints made on a white base, semipaste and ready mixed (2d ed.); C 94, specification for black paint, semi-paste and ready mixed (2d ed.); C 103, specification for water-resisting spar varnish (3d ed.). Copies of the above can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5 ct. each.

Concrete Arch Bridges with Partially Fixed Ends

Interesting examples of bridges of the above type, designed and erected in England under the supervision of R. N. Stroyer, are described by him in a recent issue of Concrete and Constructional Engineering, of London.

Figure 1 shows the section of the Coppermill bridge, Wraysbury, England, where the requirements in regard to the waterway made the mid-stream piers too narrow to constitute a fixed support for the middle arch of 50 ft. span. To increase the stiffness of the middle pier the whole of the smaller end span was designed as a closed stiff frame with a solid bottom slab connecting the end pier with the middle pier. Although to all intents and purposes the end arches might be considered as fixed in the piers, this was not the case with the middle arch, the reactions of which on the closed end frame induced certain deflections, more particularly horizontal and angular, which had to be calculated and taken into account in order to determine the final stresses in the middle arch. A similar design was used in the Langenzug bridge. In this bridge the same conditions prevailed with the exception of the bottom slab being piled instead of resting on the ground. Fig. 2 shows a section of this bridge, the spans being 60 ft. and 30 ft. respectively.

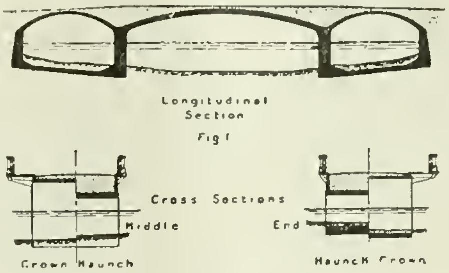


Fig. 1.—Coppermill Bridge: Typical Sections; Spans 50 ft. and 25 ft.

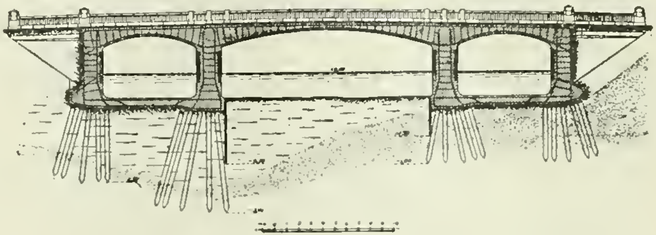


Fig. 2.—Langenzug Bridge; Section Showing Foundation Piles Driven Into Clay; Spans 60 ft. and 30 ft.

A different type of arch bridge is shown in Fig. 3, where the difficulty was due to the abutments being unable to take the horizontal thrust from an arch of about 90 ft. span. For reasons of economy some old piled abutments were to be used, and as the inclination of the old piles was very slight the resistance to thrust was correspondingly small. A number of piles with a strong batter were driven behind the old abutment, and in order to obtain weight enough to make them active as thrust absorbers a cantilever arm was extended behind the arch proper. Even then the piles were unable to take the full thrust from the various conditions of loading, but the cantilever, apart from acting as a loading platform for the skew piles, fulfilled another important object, viz., that of inducing a negative bending moment in the abutment, which again caused a diminution of the thrust to safe limits. In this case, therefore, an abutment which would give way to the ordinary arch action was endowed with a negative thrust, which acted as a set-off to the positive thrust from the arch.

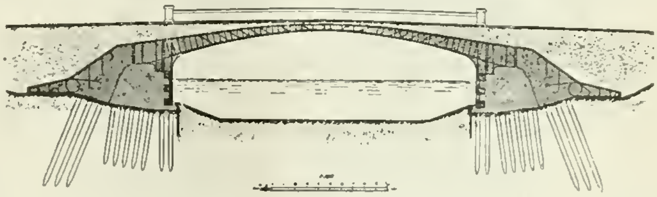


Fig. 3.—Schaartor Bridge: Section Showing Old Mass Concrete Foundation Blocks Embodied in New Structure.

Works Councils as Investigated by National Industrial Conference Board

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Summary of Report on a Year's Investigation Covering 800 Councils Shows Importance of the Movement

In an effort to find a way out of the existing tangle in industrial relations, an increasing number of firms are establishing some form of employe representation in their plants and with generally favorable results. That this tendency is not confined to any one section of the country is brought out in a recent investigation by the National Industrial Conference Board, 10 East 39th street, New York, covering nearly 800 such plans, the results of which are summarized in its Research Report No. 50, "Experience with Works Council in the United States," just published. Earlier reports of the Board on the same subject covered experiments with works councils prior to 1919, and outlined the more common forms of organization. The present study was undertaken in April, 1921, to furnish grounds for estimating the value of employe representation in industry on the basis of actual experience.

Detailed questionnaires were sent to executives in the plants known to have such organizations, and the information thus secured was supplemented by further correspondence and by visits to about twenty-five selected establishments which had had extended experience with the various forms of works councils. On these visits employe representatives and other employes, trade union officials, foremen and other plant officials were interviewed.

The report shows the sharp difference between the plans whose inauguration was forced by war necessity and those developed later by voluntary action of the two parties concerned. Most of the "Shop Committees" set up by the National War Labor Board and the Shipbuilding Adjustment Board have ceased to function, the common explanation given being that they were imposed upon the plants by an outside body, usually after a dispute between employer and employes, and that neither side desired their establishment or was willing to give the genuine co-operation necessary for a fair trial of their possibilities.

Importance of Co-operation.—On the other hand, where management and men have worked together with a common interest in the experiment, practically every plant reports an improvement in relations between employer and employe, attributable to the opportunity to come into direct and intimate contact and to learn each other's ideas and difficulties. Increased loyalty has been the result where employes have come to realize that they are working "with" the management rather than "for" them. The tendency at first, so far as employes were concerned, was to confine their efforts to the adjustment of complaints and personal grievances, but under intelligent guidance and interest on the part of management, a broader understanding of the questions involved has been developed in the employe representatives, who have been able to an increasing degree to make satisfactory adjustment of such minor disputes between foremen and employes. This has left the works council more free to discuss questions of interest to the employes as a whole.

Subjects Discussed by Councils. Suggestions made by employes with reference to their work may be divided into two main groups—those which would improve working conditions and those which would increase production. The former, such as the installation of a new drinking fountain or the rearrangement of lights, are relatively easy to secure. The latter, based on the practical knowledge and experience of employes, will be advanced only when employes have confidence in the fairness of management, and when the latter uses the opportunity furnished by works committees to direct attention toward the development of efficiency and economy. The attitude of foremen must be favorable to suggestions from subordinates and where this exists, the testimony of employers shows that an intelligent interest in problems of efficient production and in business economics in general can be secured. One Eastern corporation, for example, reported that during the calendar year 1920, 4,520 subjects were discussed by the works councils in fourteen of its plants, the topics being broadly grouped in the order of frequency under the headings of general service, health, wages, equipment, safety, employment, production problems, education, quality, recreational activities, work ticket, sanitation methods of manufacture, benefits and insurance, athletics, publicity, scrap, absentees and organization charges.

Where reductions in wages or in working force or a change in working schedules have been necessary, the Board's report shows that in plants which had used their works councils as a means of keeping the representatives, and through them the employes, informed of the business outlook, both for the country as a whole and for their individual concerns, the employes understood the need for such changes and acquiesced with much less dissatisfaction and ill feeling than would otherwise have been shown. As one employe expressed it: "Being told why you have to accept a cut in wages seems to soften the blow. It shows that the management thinks it worth while to go to the trouble to explain things to us. That's a whole lot better than merely posting up a notice Saturday night saying wages will be cut so much starting Monday morning."

Attitude of Foremen.—One chapter in the report is devoted to the attitude of foremen toward works councils, and another to the effect of councils on relations between foremen and employes. Reports regarding their attitude were received from 440 plants. In 352 of these it was stated that their foremen had been in favor of the plan from its inception. In 72 they had regarded it with disfavor at first, but later had come to see its effectiveness. Only 16 reported continued indifference to the plan. These figures show that the majority fell in with the idea at once, while those whose approval came later were fearful at first that installation of works councils would mean a curtailment of their authority, especially where the council was of the "committee" rather than the "industrial democracy" type. Some firms have found it worth while to have a regular plan for the education of the foremen in connection with the works committee, either through foremen's clubs or through conferences and informal discussions on industrial methods and relations, business administration, etc. In every such instance employers gave enthusiastic testimony of the value of the plan. Those foremen who have remained indifferent to works councils and their possibilities are usually men of limited vision and arbitrary disposition, who see in the councils only an organization to limit their power. Company officials, foremen and employes in various plants were interviewed on the effect of works councils on relations between foremen and employes, and in the great majority of cases all three classes were agreed that their installation had resulted in an increase of good will and contentment on the part of the workers.

Character of Employe Representatives.—In certain plants the first employe representatives chosen were of the radical type, but the report shows that in the larger proportion of cases the representatives elected to the councils were the best type of men and women available in the respective departments. Three plants reported that representatives proven unfit had been removed by the employes themselves while another company reported that one of the radicals elected "was defeated for re-election because he became too much of a company man." Other employers felt that the election of such radicals might well be encouraged, for the responsibility of the position and the closer insight into the problems of administration would result in making o them better men as well as better representatives.

Effect on Labor Turnover.—The influence of employe representation in reducing labor turnover is difficult to measure because of various complicating factors and the extreme industrial depression with resulting unemployment. Th result, in any case, is likely to be produced indirectly, and conclusive evidence is lacking. A number of employers however, have expressed the opinion that labor turnover ha been decreased by the better relations created between executives and workers.

Attitude of Labor Unions.—Organized labor is officially against all plans of industrial government that does not provide for union recognition, though it does not object to a system of employes' committees in a shop if they are supplemental to a trade union agreement. The Conference Board found many employers reluctant to answer its ques tions regarding the attitude of local trade unions toward their works councils, so that an accurate estimate of the relative number of cases where active opposition was shown was difficult to obtain. Field investigation, moreover, showed that in some cases the reports of employers were at variance with the statements of union officials. Although the local unions might not have made any organized assault upon the works councils, it was found that they regarded the councils with disfavor and were doing much to induce employes to put no faith in them. The common belief among union officials was that under a works council system the work of organizing the employes was made more difficult. Employes intended to drop their union membership because they could gain advantages through the works council that cost them nothing, whereas the unions demanded fees for their support.

Employers' Opinions of Value of Councils.—The last part of the report is given over to employers' opinions as to the value of works councils in industry. These show that much depends on the manner of their installation and the sympathetic attitude and co-operation of both management and workers. The importance of continued interest on the part of employers as well as employes is emphasized. Works councils have been found of special value in large organizations where the size of the plant and the number of workers make difficult any degree of personal and friendly contact between management and employes, and this one point, more than any other, is cited by employers whose experience with works councils has led them to endorse their operation.

360 Ft. Steel Arch Has Protective Covering of Gunite

A highway bridge having some out of ordinary features has been completed recently over the Willamette river at Oregon City, Ore., for the Oregon State Highway Commission. The following notes on this structure are taken from the Contract Record.

The structure is 850 ft. in over all length, having two concrete approaches of the beam and girder type and a center arch of 360 ft. center to center of piers or 350 ft. between skew backs. The arch is composed of structural steel with a protective covering of gunite.

The bridge is the connecting link in the highway between Oregon City and Portland and is subjected to exceptionally heavy truck traffic, as well as a large volume of pleasure and pedestrian travel, and is exposed to an atmosphere which is at times more or less charged with sulphurous anhydride. The location of and condition surrounding the bridge, therefore, constituted an engineering problem which required considerable thought.

This design consists of a 360 ft. arch with the two concrete approaches with a roadway of 19 ft. clear and two 4 ft. 6 in. sidewalks. It is designed as a half-through span to provide the required vertical and lateral clearance for navigation.

In erecting the structure the steel ribs were erected first and swung into place as a three-hinged arch. As soon as this was done, and the lateral system was in place, 30 ft. of the rib at each skew back was completely encased and filled with concrete, thus rigidly fixing the ends. The crown hinge was then replaced by a heavy splice plate connection designed to transmit the maximum thrust, moment and shear, at the crown. This done, the rib became a fixed member or a hingeless arch.

The main arch rib was of the box girder type and was composed for the rib, of four 8x8x⅝ flange angles, two web plates ½ in. x 120 in. (approx.), four flange plates 16 in. x ⅝ in., six longitudinal stiffener angles 6 in. x 3½ in. x 5/16 in., and two longitudinal stiffeners 6 in. x 6 in. x ⅜ in. The crown was composed of four flange angles 6 in. x 6 in. x ⅝ in., two cover plates 30 in. x ½ in., two web plates 72 in. x ⅜ in., and six longitudinal stiffener angles 6 in. x 3 in. x 5/16 in.

Diaphragm plates were used to stiffen the rib. These plates had manholes cut in same so as to allow inspection of the inside of girder at all times. Manholes were also left in the cover plates at convenient points to allow access to the girder. These were covered with removable hatches.

After the steel arch was completed the inside of girders was given a ¾ in. covering of gunite and the outside a 1½ in. covering. The floor members, struts and hangers were all of structural steel encased in gunite. The total cost of the structure was $213,602.

Replacement of Building Trades Workers

How many new workers are needed each year in the building trades? That question is of fundamental importance to a rational study of our needs in the field of apprenticeship and of trade schools. An answer to this question is given by Milan V. Ayres, Statistician and Aanalyst of the Associated General Contractors of America, in the August issue of The Constructor, from which the matter following is taken.

TABLE I.—MEN IN BUILDING TRADES IN UNITED STATES IN 1920 GROUPED BY AGE PERIODS.

ARTISAN	17-19	20-24	25-44	45-64	65 and over	Unknown	Total
Carpenters	16,541	59,178	412,626	332,064	65,436	1,363	887,208
Painters, glaziers and varnishers (building)	4,377	16,053	126,288	86,972	14,398	306	248,394
Electricians	13,818	47,579	127,309	22,883	1,114	242	212,945
Plumbers and gas and steam fitters	6,894	30,636	124,078	42,213	2,654	240	206,715
Brick and stone masons	1,352	7,760	62,707	49,252	10,024	162	131,257
Tinsmiths and sheet metal workers	2,378	8,535	37,875	18,140	2,904	93	69,725
Plasterers	337	2,259	19,650	13,393	2,517	93	38,249
Stone cutters	305	1,340	10,911	8,319	1,201	20	22,096
Structural iron workers	394	2,269	12,151	3,842	154	26	18,836
Paper hangers	268	1,058	9,398	6,618	970	26	18,338
Roofers and slaters	295	1,163	6,255	3,236	417	14	11,378
Cement finishers	63	405	4,553	2,411	171	18	7,621
Coppersmiths	212	755	2,853	1,271	136	5	5,232
Total	47,264	178,990	956,432	590,614	102,096	2,598	1,877,994

New workers are needed for three purposes: To take the place of those who die and of those who retire, and to provide for the increase which should accompany a growing population. It is evident that the number of deaths and retirements, in any trade, will depend largely upon the ages of the men engaged in that trade, since old men die faster and retire sooner than younger men. Table I shows the number of people engaged in 13 of the building trades and their distribution by age periods, according to the 1920 census.

TABLE II.—NEW MEN NEEDED ANNUALLY IN BUILDING TRADES PER THOUSAND IN EACH TRADE.

ARTISANS	Replacement		Increase	Total
	Death	Retirement		
Brick and stone masons	17.6	5.0	14.0	36.6
Carpenters	17.4	4.8	14.0	36.2
Plasterers	16.6	4.3	14.0	34.9
Stone cutters	16.4	3.6	14.0	34.0
Painters, glaziers and varnishers (building)	16.2	3.8	14.0	34.0
Paper hangers	15.2	3.4	14.0	33.6
Tinsmiths and sheet metal workers	13.9	2.7	14.0	30.6
Roofers and slaters	14.0	2.4	14.0	30.4
Cement finishers	13.9	1.5	14.0	29.4
Coppersmiths	12.4	1.7	14.0	28.1
Plumbers and gas and steam fitters	11.5	.8	14.0	26.3
Structural iron workers (building)	11.3	.5	14.0	25.8
Electricians	9.3	.4	14.0	23.7

The figures given should not be used without reservation as representing the number of workers engaged in building construction, because the census classifications are such that many of those included in some of these groups are working in factories or in other pursuits not connected with the erection of new buildings. With this reservation in mind,

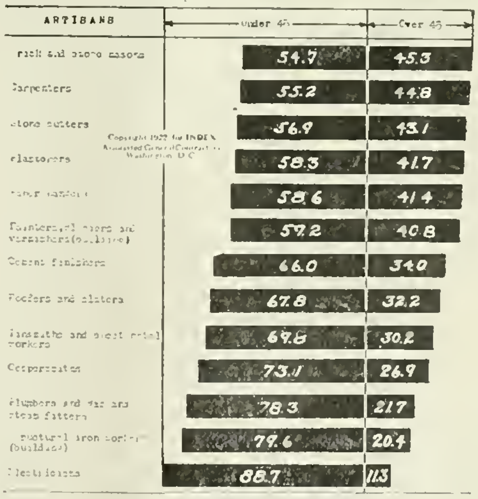


Fig. 1.—Percentage of Men in Building Trades Who Are Over and Under 45 Years of Age.

however, they may be satisfactorily used for the purposes of the present study.

The bars in Fig. 1 show what proportion of the men in each of these trades are over 45 years of age, and what proportion are under that age. It is obvious that the men at the head of this list must be dying off much faster than those at the foot.

Those trades which show the greatest proportion of younger men are those which have been recruited largely from young men in recent years. Those with the greatest proportion of older men are the trades which have been receiving relatively few additions from among the youths. The latter are trades whose numbers have been growing slowly or even decreasing, while the former are the rapidly growing trades.

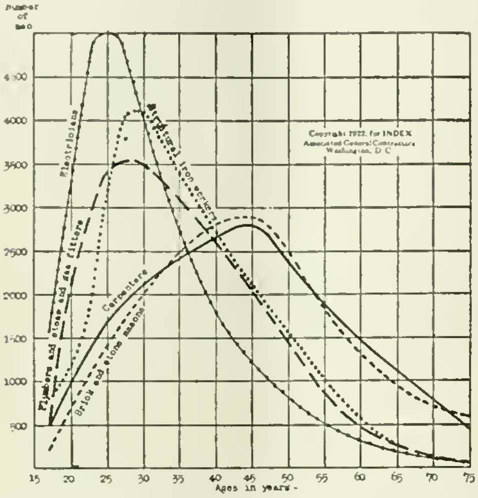


Fig. 2.—Age Distribution of Men In the Building Trades—Number of Men at Each Age Out of Every 100,000 Total Engaged in Each Trade. Illustration: Of Every 100,000 Carpenters There Are 2,400 Who Are Over 50 Years Old; Of Every 100,000 Electricians, 5,000 Are 25 Years Old.

It is unfortunate that the figures at present available from the Census Bureau do not give us a more detailed age distribution. It would be much better for our present purposes if we knew the number in each 5-year group, that is, the number aged 20 to 24, 25 to 29, 30 to 34, etc. However, it is possible from the figures given in the above table to construct curves which must represent very nearly the correct distribution, by ages, of the various trades.

Figure 2 shows such a distribution for five important building trades. The curves show for each trade the number of men at each age from 17 to 75; for every 100,000 electricians, for instance, there are 1,550 who are 17 years old, 5,000 who are 25 years old, and 1,800 who are 40 years old. Similarly, there are 500 carpenters who are 17 years old and 2,800 who are 45 years old.

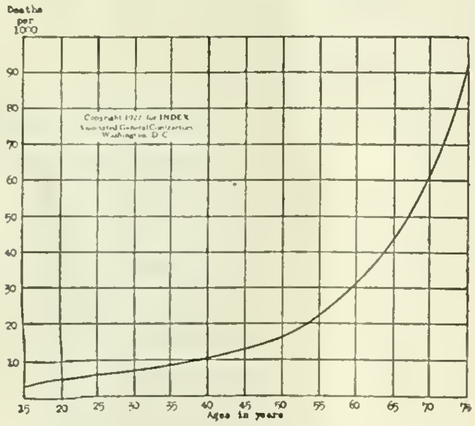
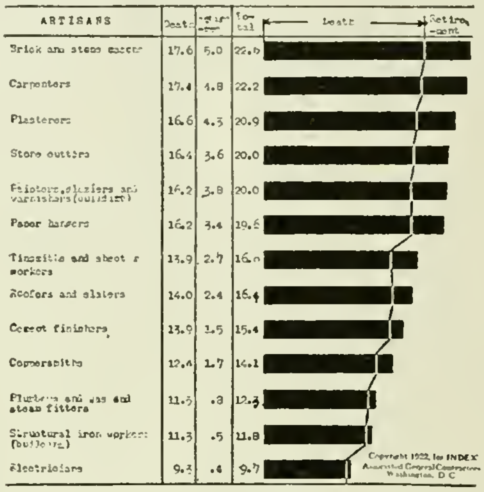


Fig. 3.—Annual Deaths per 1,000 at Each Age Among Men in United States.

Figure 3 shows how the death rate varies among the male population of the United States, according to the life tables prepared by the United States Census Bureau. At age 17, the death rate is 3.65 per thousand; at age 50 it is 15.81, and at age 75, 92.72. A comparison of this curve with the five curves showing age distribution will make it at once evident that the dath rates among carpenters and masons must be much greater than among electricians, plumbers or structural iron workers.

Figure 4 shows the number of deaths and the number of retirements to be expected each year among each of the 13 trades as a consequence of the age distribution. In making these computations, we have assumed that all of the workers shown in each age group remain in their trade until they die or reach the age of 75 years, and that all who reach the age of 75 thereupon retire.

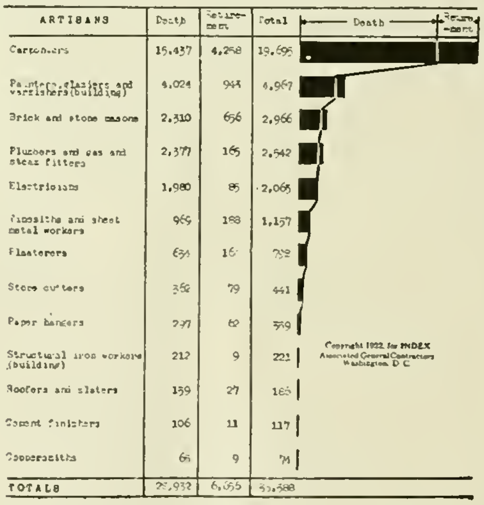
Of course, as a matter of fact, many retire before reaching 75 years of age, but this will not greatly affect the total net result. It will merely increase the retirements and decrease the deaths by very nearly equal amounts. It is evident from these figures that, with present age distribution, some trades require annually more than twice as many new men as are required by others, merely to keep the total number of workers in the trade at a constant figure.



ARTISANS	Death	Retirement	Total
Brick and stone masons	17.6	5.0	22.6
Carpenters	17.4	4.8	22.2
Plasterers	16.6	4.3	20.9
Stone cutters	16.4	3.6	20.0
Painters, glaziers and varnishers (building)	16.2	3.8	20.0
Paper hangers	16.2	3.4	19.6
Tinsmiths and sheet metal workers	13.9	2.7	16.6
Roofers and slaters	14.0	2.4	16.4
Cement finishers	13.9	1.5	15.4
Coppersmiths	12.4	1.7	14.1
Plumbers and gas and steam fitters	11.5	.8	12.3
Structural iron workers (building)	11.3	.5	11.8
Electricians	9.3	.4	9.7

Fig. 4.—New Men Needed Annually per Thousand In Each Trade to Replace Those Who Die and Retire.

The total number of men actually needed each year for this purpose in each of the trades is shown in Fig. 5. This number varies from nearly 20,000 carpenters to only 74 coppersmiths. The enormous range of this requirement is of course due much more to the great range in the total numbers actually employed in the various trades than to the variation in the death and retirement rates.



ARTISANS	Death	Retirement	Total
Carpenters	15,437	4,258	19,695
Painters, glaziers and varnishers (building)	4,024	943	4,967
Brick and stone masons	2,310	656	2,966
Plumbers and gas and steam fitters	2,377	165	2,542
Electricians	1,980	85	2,065
Tinsmiths and sheet metal workers	969	188	1,157
Plasterers	634	158	792
Stone cutters	362	79	441
Paper hangers	297	62	359
Structural iron workers (building)	212	9	221
Roofers and slaters	159	27	186
Cement finishers	106	11	117
Coppersmiths	65	9	74
TOTALS	28,932	6,655	35,588

Fig. 5.—New Men Needed Annually in the United States in Each Trade to Replace Those Who Die and Retire.

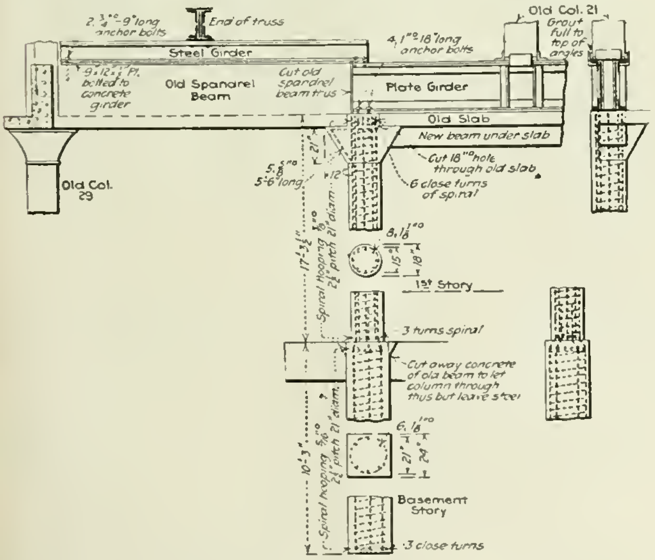
The population of the United States during the decade from 1910 to 1920 increased at a rate equal to 1.4 per cent each year. This is equal to an increase of 14 per thousand. If this rate is still continuing, it is evident that each trade, in order to keep pace with the growth of population, must not merely keep its numbers intact, hut, in addition, must add, each year, 14 new workers for every one thousand already in the trade. It, therefore follows that, although at present only 9.7 new men are required to take the place of those electricians who die and retire each year, an additional number of 14 are required if the trade is to grow with the population, making a total of 23.7 new electricians required each year for every 1,000 already in the trade. The next table shows how this works out for each of the 13 trades; it results in the minimum requirement of 13.7 per thousand for electricians, and 36.6 per thousand for brick and stone masons.

Constructing New 10-Story Building On and Around Old 4-Story Structure

Whether to make over the old structures or to wreck them and build all new, is a problem that is ever recurring in the building business. Such a problem was successfully solved in connection with the construction of the 10-story and basement reinforced concrete United States National Bank building at Denver, Colo. The building is flat slab construction throughout and was erected on and around a 4-story building of the same general design. The following account of this work is taken from an article by Walter H. Wheeler, Consulting Engineer, in The Improvement Bulletin.

It has been generally considered that the remodelling of a reinforced concrete building, and especially one of flat slab construction, would be extremely difficult and expensive. In this case, however, the work was carried out expeditiously and economically. It is worth while to note that the old building was of concrete made from a mixture of gravel and blast furnace slag, and the embedded steel showed no signs of corrosion when exposed.

General Features of New and Old Buildings.—The new building covers a ground area 125 ft. square and is 10 stories and basement with mezzanine in first story and a 2-story pent house. Included in this structure is the reinforced concrete frame of the old Century building, constructed in 1908-9 by the Jones-Wheeler-Cranmer Engineering Co., on the Turner "Mushroom" system flat slab reinforced concrete, with a standard column capitals without depressions. The Century building was 125 by 75 ft, four stories and basement, with columns and column footings designed to carry four addition stories. The building was used for retail stores on the first floor and offices above. In one of the stores under the wall of the east light court four cast iron columns were used. The vertical column bars for these columns were concreted into the cast iron columns and bent out at the top into the slab, and the spandrel beams supporting the light court wall were turned above the slab to eliminate the beams from the ceiling.

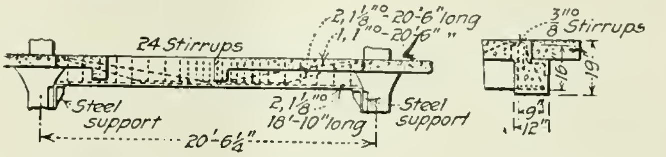

2, 3/4"⌀-9" long anchor bolts
End of truss
Steel Girder
4, 1"⌀ 18" long anchor bolts
Old Col. 21
Grout full to top of angles
9×12×½" Pl. bolted to concrete girder
Old Spandrel Beam
Cut old spandrel beam thus
Plate Girder
Old Slab
New beam under slab
Cut 18"⌀ hole through old slab
6 close turns of spiral
5, 5/8"⌀ 5'-6" long
21"
12"
Old Col. 29
17'-3½"
Spiral Hooping 5/16"⌀ 2½" pitch 21" diam.
8, 1⅛"⌀
15"
18"
1st Story
3 turns spiral
Cut away concrete of old beam to let column through thus but leave steel
10'-3"
Spiral hooping 5/16"⌀ 2½" pitch 21" diam.
6, 1⅛"⌀
21"
24"
Basement Story
3 close turns

Detail of Reconstruction Work at Column 21.

In the new building the ground area was increased to 125 ft. square and the whole structure carried up the full 10 stories. The old columns and column footings were determined to be safe for carrying the additional stories, by using hollow tile backing for the outside walls and court walls above the fourth story on the old part of the building.

Slag Used Is Aggregate in Old Concrete.—At the time the old building was constructed, there was considerable criticism of the use of blast furnace slag in the concrete aggregate. It was urged that the water used in mixing the concrete would form sulphuric acid with the sulphur in the slag and cause disintegration of the concrete and corrosion of the steel. Chemical analysis of the slag convinced the builders that there was no danger from this source and examination of the old concrete and steel during the remodeling of the old building proved this conclusion was correct.

Fire Test of Flat Slab Construction.—At the time the old building was constructed, reinforced concrete and particularly flat slab construction, was new in Denver. The building department therefore insisted that a fire, load and water test be made on the first floor slab. A panel was selected for this test, which had been slightly frosted by a sudden cold snap the night after it was poured. Thirty-three tons of pig iron was placed on this panel over a rectangular area considerably smaller than the full panel area, this load being over twice the design load for the whole panel. A large wood fire was built under the loaded slab with the flames striking the slab for about twenty minutes and the temperature brought up to 1,800° F. according to the inspector's record. A stream of water from a fire hose was then turned against the bottom of the slab. After the fire and before the load was removed the deflection of the slab at the center of the span was 5/32 in., which was less than half the deflection allowed under the ordinance.



Detail of Beam Support of Joint Between Old and New Floor Slabs.

Alterations in Old Structure.—In constructing the new building it was found necessary to make extensive alterations in the old concrete structure to harmonize it with the plans for the new building. The old concrete roof of the interior light court which is about 45 ft. square, was all removed and steel trusses placed spanning the light court to form a large central skylight over the center of the banking room about 30 ft. square and two stories high. The space around this skylight was roofed over with new concrete slab at the level of the second story window sills, so that the light for the second floor offices was not interfered with.

One of the main columns (Col. 21) in the first story of the old building which supported the walls of this interior light court interfered seriously with the plan of the new banking room and it was decided to cut this column out in the first story and support it on a box plate girder built into the light court wall in the second story and carried on two new reinforced concrete columns built into the basement and first story in the location required by the plan to conform with those on the opposite side of the light court, thus carrying nine stories on this new girder.

It was intended that the new girder should be in place before any stories were added to the old part of the building. This would have permitted carrying the old floors on supports placed under the spandrel beams at either side of column 21 while the change was being made. Delivery of the girder was delayed, so that in order not to hold back the construction of the building, arrangements had to be made for cutting off the old column and placing the girder under it after the floors above had all been poured and the forms and reinforcing for the roof were in place. The load on the old column, including its own dead weight, which had to be supported during this operation, was about 130 tons.

How the Old Column Was Supported and Girder Placed.—The method used to support the old column and place the girder is shown in the illustrations. Wood shoring was placed under the slabs around the old column from the basement floor to the fifth floor. Above the fifth floor the forms were left in place and reinforced with additional shoring. A temporary brick arch was built on top of the old second floor spandrel up to the bottom of the third floor slab and spandrel to support the weight of the column itself and that part of the slab and wall loads not carried by the shoring. In cutting off the old column a hacksaw was used to cut out one of the vertical column bars and after the column was cut through and swinging free this section of the old bar was set back on the stub from which it was cut, and it was found that no settlement had taken place. The contractors on this work are entitled to much credit for the care with which they performed this delicate task.

The columns and footings of the old building along the line of connection with the new part of the structure were originally designed with a view to possible future extension of the building. The slabs along this line were built without spandrels, the flood load and tile walls being carried by the slabs. No settlement was found in these slabs when the walls were removed, which would indicate that where this system of reinforced concrete construction is used, a smaller part of the floor and wall loads may be legitimately figured on the spandrels than is customary.

Ingenious Method Employed in Connecting New and Old Beams.—At the connection of the new and old slabs shallow concrete beams were cast at the edge of the new slabs projecting half the width of the beam under the edge of the old slab. These new concrete beams were supported by steel brackets on light steel channels strapped to the old concrete columns by steel bands. It was not permissible to place new concrete columns against the old columns or to increase the old columns in size because of the marble work in the banking room, which accounts for the method used. Steel channels were selected of such a size that the flanges would fit around the edges of the old octagon columns, by cutting a shallow groove in the concrete and permit the inner faces of the channels to fit sung against the concrete columns.

The connection of the new spandrel beams of the light court to the old columns proved to be another problem. At the second floor level there were full column capitals on the old columns. Heavy steel straps were placed around the old columns at the proper level to receive the ends of the bars in the new beams and pockets dug in the sides of the old columns to receive the ends of these bars which were hooked around the straps. The old spandrels in the light court were all turned above the slabs and the new second floor spandrels were also turned up to clear the banking room ceiling of beams. There were no column capitals on the old columns at the third, fourth and fifth floor levels, and the new spandrels for these floors were connected to the old columns by steel straps as at the second floor, but the loads were carried by heavy steel stirrups, which hung the ends of the new third, fourth and fifth floor spandrels from the sixth floor. These stirrups were built into the brick walls to protect against damage by fire or corrosion. All steel work, including the steel straps on the columns, was protected by a casing of Portland cement concrete.

To provide for the stairway to the safe deposit vaults in the basement and also the main stair from first to second floors it was necessary to remove one entire panel of the first floor and reconstruct it at two new levels. The edges of the new opening were supported on new concrete beams cast under the old slab. Some of these beams were connected into old columns and some into old concrete beams under the old floor. The boiler breeching prevented the use of any stub columns or walls in the basement. The location of the stack was changed, and the old openings in the slabs were filled and new openings cut in the second, third, fourth and fifth floor slabs to let the stack through, which also had to be framed with new beams cast under the old slabs. A new opening was cut for the main stairway through the old second floor slab and also framed with new beams. Above the second floor the new stair is in the new part of the building. It was also necessary to fill in new slabs in old openings in the old first floor which had no beam framing around them. Wherever new concrete beams were cast under old slabs, holes were cut at intervals through the old slabs and the new concrete beams poured through these holes, stirrups being placed in the holes which were filled with concrete.

It was necessary to strengthen the old cast iron columns in the first story. They were hooped with expanded metal mesh well lapped and tied and encased in concrete poured through holes in the second floor slab.

To carry the mezzanine floor slab, the old columns were hooped with ties and vertical reinforcing bars and 4 in. of concrete cast around the old columns when the mezzanine was poured. In this location the old columns could be increased in size without interfering with the marble work. Several of the old columns in the basement story under the mezzanine floor were also encased with concrete in a similar manner to strengthen them for the new loads.

The general contractors on the work were C. S. Lambie Co. of Denver. W. E. & A. A. Fisher of Denver were architects on the building, and Weary & Alford Co. of Chicago were architects on the bank interior. Walter H. Wheeler was designing and consulting engineer on the reinforced concrete and structural steel work. The new part of the building is all Turner "Spiral Mushroom System" flat slab construction with standard column capitals and no depressions. The spans range from 14 ft. to 26 ft. The first floor is designed to carry 125 lb. live load and the floors above 75 lb. live load per square foot.

Converting Artificial Ice System Into Temporary Heating Plant

When Mme. Galli-Curci sang in Vancouver, B. C., last March the only auditorium of sufficiently large proportions to accommodate the expected audience was the Arena skating rink. Vancouver is the place where they have to make artificial ice for their skating rink, even in winter. But the cold storage atmosphere was not conducive to the best efforts of even a prima donna, to say nothing of the comfort of the audience. It was, therefore, decided to heat the arena. The idea was to reverse the usual process by which the ice on the skating floor was formed. The problem was put up to the engineering department of the B. C. Electric Ry. Co. How they solved it, the installation and test being completed in 48 hours—incidentally it is the first time on record when such a method of heating electrically was ever tried, is told in The Contract Record. The results were entirely satisfactory, the large audience which packed the great arena enjoying the concert with all the comfort of a theater.

The circulating pipes for the artificial ice system are installed in parallel lines between parallel headers laid in sand under a hardwood floor, on which the ice film is ordinarily formed. There are 53,500 ft. of this pipe, which is 1¼ ins. in diameter. To heat these coils the method adopted was as follows:

Three sections of ¾ in. pipe, 250 ft. long, were coupled in delta and immersed in the 25,000 gal. brine tank. After being heated to pre-determined value, the water was circulated by a 600 gal. centrifugal pump. Elements were supplied by a 650 kw. transformer, 2,200/110 volts, coupled in parallel delta, the current on the 2,200 volt side being 90 amperes.

After heating the tank water for 24 hours, the temperature of the water in the tank was raised in that time to 160° F. and then circulated by means of the pump through the pipe system for three hours. The following figures show the result:

Before circulating: Temp. of tank water, 160°; temp. of floor, 49°; temp. outside building, 43°.

After circulating 3 hours: Temp. of tank water, 106°; temp. of floor, 59°; temp. outside building, 41°.

During the 30 hours' run in which the temporary heating plant was used, the power required was 9,000 kw. hours. To give a more definite idea of the heating problem solved in this original manner, the following dimensions are given:

Height of building, ft.	60
Width of building, ft.	135
Length of building, ft.	260
Area of exposed walls, sq. ft.	47,400
Brine tank capacity, gal.	25,000
Piping system capacity, gal.	5,000
Lin. ft. pipe under main floor, ft.	53,500
Size of pipe, in.	1¼

New Method for Determining Total Nitrogen in Steel.—Preliminary tests by the U. S. Bureau of Standards of a new method for determining both combined and uncombined nitrogen in iron and steel confirm the belief that the method will determine and make more certain the extent of uncombined nitrogen in steel, namely, nitrogen which is not determined by the Allen method. The new method depends on the absorption in calcium vapor of all the gases evolved from the steel sample when fused in vacuo. The nitrogen is fixed as calcium nitride which is then readily determined by solution in acid and distillation with sodium hydroxide.

Heat Transmission in Wall Materials

A report dealing with experiments on the transmission of heat and gases through, and the condensation of moisture on the surfaces of, wall materials has been issued by the British Building Research Board. The following abstract of the report is taken from The Surveyor, London.

The tests were carried out in a laboratory under carefully considered conditions, namely, in still air with walls consistently dry. The results obtained (given in full in an appendix to the report) are summarized below:

Heat Transmission Through Thin Walls.—When heat is passing from a region of comparatively high temperature through a partition of some kind to a region of low temperature the heat transmitted can be said broadly to depend on (1) the construction and material of the wall; (2) the character of the surface of the wall; (3) the area of wall; (4) the temperature difference between the regions of high and low temperature.

Th actual heat transmitted in British thermal units in still air will then for any particular case be given by the formula

$$H = K (t_1 - t_2) A$$

where

H = British thermal units transmitted per unit time.
t_1 = Higher temperature in degrees Fahrenheit.
t_2 = Lower temperature in degrees Fahrenheit.
A = Area of wall in square feet.
K = A constant, depending upon construction and material of the wall and condition of the surface.

It will be seen then that the constant K (sometimes termed the co-efficient of transmission) will be a measure of the efficiency of the wall as a heat insulating structure, representing the overall value of the transmission in British thermal units per square foot per hour per degree difference of temperature, on the two sides of the wall.

Values of this constant K are given in the bottom line of a table which also embodies the full experimental results. These values are given below:

Type of Wall.	Value of K.
9 -in. plain unplastered brick wall (London stock)	0.43
4½-in. plain brick wall unplastered	0.57
4½-in. double brick wall 3-in. cavity (without ventilation)	0.33
4½-in. double brick wall 3-in. cavity (ventilated top and bottom)	0.42
4½-in rough ballast concrete 6 to 1	0.61
4½-in. rough breeze concrete	0.55
6 -in. rough ballast concrete	0.57
9 -in. concrete blocks with cavity in each block	0.52
4 -in. thick hollow brick tile	0.44
4 -in. ballast concrete wall outside 2-in. cavity and 4-in. coke breeze concrete inside (without ventilation)	0.30
4 -in ballast concrete wall outside 2-in. cavity and 4-in. coke breeze concrete inside (ventilated top and bottom)	0.35

Thus, of the walls tested, the 4½-in. rough ballast concrete wall offers the least resistance, while the 10-in. concrete cavity unventilated wall with the inner partition of coke breeze offers the greatest resistance to the flow of heat. The latter type of wall doubtless partly owes its efficiency as a heat insulator to the porous nature of the breeze, as it is of course a well known fact that good insulators such as cork, slag wool, or wood owe their insulating properties to the large number of small air spaces contained within their mass.

It will be noticed that in these examples the difference in the value of K with a cavity wall when ventilated and not ventilated appears to be small; but the effect of ventilation on the transmission of heat is governed by the extent to which circulation occurs in the cavity under ordinary weather conditions. This will depend upon the force of the wind and on the difference between the temperatures of the inner and outer atmospheres. Either or both of these factors might have the effect of increasing the circulation if ventilation is provided both at the top and bottom of the cavity.

It may be said, therefore, that comparatively little is lost in the insulating effect of the wall by providing a limited amount of ventilation in the cavity, particularly if this is arranged at the base of the cavity only.

The loss of heat in all the walls may be greater under actual conditions than these tests indicate, owing to the increased cooling effect which would be produced by the action of wind or the evaporation of damp on the external surface of the wall. This might reduce the temperature of the external face of the wall by as much as 2 or 3 degrees below that of the surrounding air, depending upon the wet bulb temperature obtaining at the time.

Porosity of Building Materials.—The tests on the porosity of various materials roughly consisted in drawing or forcing air, hydrogen, coal gas or carbon dioxide through slabs of the selected material. The pressure on either side of the slab was measured by means of manometers, the amount of gas forced through in a given time being determined by passing the gas through a meter. Pressure differences ranging from 16.7 lb. per square foot to 100 lb. per square foot were employed.

The rate of flow through any given slab was found roughly to depend upon the co-efficient of viscosity of the gas and varied in proportion to the pressure up to 80 lb. per square foot.

In some cases specimens from different sources were tested in order to determine the degree of uniformity which could be expected due to variations in material and methods of construction.

The following materials were used: Fletton brick, stock brick, concrete (ordinary mixing), concrete (dry mixed and rammed), coke breeze, coke breeze (rendered).

The amount of air passing through a wall of given size varies in proportion to a constant which depends upon the material. This constant, called the porosity, is equal to the amount of air in cubic feet that would be forced through one foot thickness of material one square foot in area by a pressure of 1 lb. per square foot in one hour.

The results show that the concrete slabs were very much less porous than the brick, the porosity being .0014 for the former and .13 and .17 for Stock and Fletton bricks respectively. It is doubtful, however, whether this difference would be so marked in an actual building, since concrete made in small quantities for test purposes is likely to be more thoroughly mixed and rammed than would be the case in practice.

The porosity of the coke breeze and cement samples tested was 960 in one case and 14 in the other, the samples having been obtained from two different sources. The difference in structure was evident on inspection.

In the case of the bricks it was found that variations in results could be traced to distinct fissures, the leakage through which could be felt by hand when air was forced through at the higher pressures. When these leaks were stopped up the porosity was diminished by some 20 per cent.

It would appear, then, that leakage through defective joints may be far more important than the porosity of the actual material used.

Porosity of Wall Plaster.—Some preliminary experiments were made with plaster applied to coke breeze blocks, but unsatisfactory results were obtained owing to the low porosity of the breeze foundation.

For the main tests the plasters were applied to an expanded metal foundation. The slabs were finished on one surface so that one-half the area of one surface was smooth, the remainder half being left rough. The back of the slab was also left in the rough state.

Dealing with this series, it is shown by a table in the report that plaster materials generally are relatively porous except for the fine setting coat which in the case of common plaster makes the material twenty times as resistant to the passage of air. The results are given for the actual thicknesses of plaster tested.

Though the results show that the various materials differ in porosity the difference does not seem of great importance in view of the small quantity of air which would pass through the material of a wall in practice.

Assuming a room 15 ft. by 10 ft. by 8 ft. with the longer wall exposed to an air pressure of 1 lb. per square foot which corresponds to a strong wind, and taking a porosity of 0.2 for a 9-in. wall and 0.2 also for ¾-in. plastering, and taking 0.1 as the combined porosity of the two, only 12 cu. ft. of air per hour will pass through the wall. This is only 1 per cent of the capacity of the room.

The effect of a crack in a 9-in. wall has been estimated by a calculation of the amount of air which will be forced through a fissure 1/16 in. wide and about 1 ft. in length, by the same pressure. This would be in the neighborhood of 200 cu. ft. per hour. Thus the small crack will pass many times the amount of air which will percolate either through the bricks and plaster or through an unplastered wall. In most rooms natural ventilation of something like one change per hour will occur often with doors and windows closed. For the room in the example this amounts to 1,270 cu. ft.—hence it will be seen that percolation through brick-work and plaster is negligible.

The Costliness of Corrosion

Editorial in The Engineer, London.

At a meeting of the Royal Society Sir Robert Hadfield reached the astounding estimate that the total sum spent annually to counteract the ravages of corrosion is probably well over five hundred million pounds per year! It is impossible, obviously, to check that figure, and it is of small consequence whether it is a few millions too great or too small. It serves its purpose in directing attention to the cost to which the world is put by the slow decay of metals, and brings before us the fact that unless corrosion is checked, the known iron ore resources of the world must be exhausted within a measurable distance of time. Sir Robert quoted the opinion of Professor J. W. Gregory that if the output of iron should continue to increase at the rate that obtained before the war, then in no more than a century and a half the world supplies would be exhausted. It is, we admit, a little bit difficult to be moved by the probable events of A. D. 2070. The everyday fact which we all have to face in a greater or less measure that pounds, shillings and pence have to be expended in the effort to preserve iron and steel parts from rusting by painting, and on the replacement of them when, despite all our care, they have been eaten away, is much more likely to bring home to us the serious nature of corrosion. On one important structure alone—the Forth bridge—over ten thousand pounds were spent in the twelve months ending June, 1921, on painting and repairing. That structure weighs in round numbers 51,000 tons, so that something approaching four shillings per year has to be spent for every ton weight of the structure. If we take an annual world output of pig iron of, say, eighty million tons, and allow that on every ton, whether converted into steel or not, four shillings a year has to be spent on painting, we reach a total of sixteen million pounds per annum on new constructions alone. As hundreds of millions of tons of old structures have also to be preserved, the enormous cost involved may be imagined.

These figures, rough as they are, bring home to us the costliness of corrosion, and force us to recognize that amongst all researches in the scope of engineering, there is none that could do more to effect economy than the discovery of the means of arresting the decay of metals without the constant application of paints and protective coatings. The problem is an ancient one, and for many years past it has been attacked by researchers in all parts of the world. But even after prolonged scientific study and experimental inquiry, there is no unanimity of opinion as to the chemical reactions which takes place in the formation of rust. While differences can exist about an elemental fact, it is almost hopeless to look for a scientific solution of the problem of corrosion, and we must hope rather to blunder upon it—if it is attainable—by the despised method of trial and error than by intelligent reasoning. We are, indeed, as Sir Dugald Clerk said in a few brief remarks upon Sir Robert Hadfield's paper, obliged to follow the inductive method, piling up observations upon observations in the hope that some day useful deductions may be made from them. Unfortunately, the method is an extremely slow one. It would appear that corrosion is a very delicately balanced reaction, or system of reactions, for we know that a very small change in the conditions may have a marked effect upon the results. We are therefore without a standard by which to compare results. Iron that is almost pure resists corrosion, but so does iron or steel that contains a heavy percentage of chromium or nickel or a trace, one-quarter of one per cent. of copper. But even such irons and steels as these will not resist it in all cases, and while some do not corrode at all, others, by the corrosion itself, set up a protective mantle which inhibits further action. In the stainless steels—discovered accidentally by Mr. Harry Brearley—and in the more recent arrivals known as rustless iron, we have extremely useful materials which have proved their qualities in many and various conditions, but we hesitate, without further knowledge, to say that a bridge constructed of either material would give satisfactory results. The evidence indicates that it should do so, but, so variable and uncertain are the ways of corrosion, that until a bridge has been actually made and left, for long, exposed to the weather it is unsafe to speak definitely, and even after such a practical test we could not assert without reserve that a similar bridge erected in another place and faced by other conditions would show the same resistance. It is to be hoped, nevertheless, that the test will soon be made. The difficulty is not price alone. The anti-rusting properties of high chromium steels depend largely upon heat treatment, and in some measure upon surface conditions. Hence the material does not lend itself to the rough treatment of the bridge yard; but in view of the great economic importance of a satisfactory result, the adoption of special precautions and special methods would, we believe, be justified.

It is known to our readers that the Institution of Civil Engineers has set up a committee for the study of the corrosion of steel in sea water, and that half the expense is being borne by the Department of Scientific Research. The institution possesses unexcelled facilities for conducting an inquiry of the kind. It can send samples of steels to all parts of the world with the knowledge that they will receive the scientific attention of trained men, and it may therefore justly hope to secure a mass of statistics and information—an accumulation of inductive facts. But it is extremely unlikely that any single great generalization will result from an investigation of the kind. So capricious apparently is corrosion, that we shall feel not the least surprise if a steel which gives admirable results in the Bristol channel is far down the list of merit when tested in the Firth of Forth, or that a steel which fails hopelessly in, let us say, the Tyne, shows astonishing powers of resistance in the Hooghly. The fact is that after years of investigation, we are very little nearer understanding corrosion than we are of understanding cancer. Both appear to be capable of great divergencies and to be subject to a variety of causes, and the best we can do is to keep on piling up observations in the hope that if they never lead to a great generalization, they may at least serve as guides to the probabilities of similar cases.

Renovating a Building with Concrete

An interesting case of renovation with important alterations in which concrete proved particularly useful was carried out at the Town Hall, Burgdorf. The ground floor of the Town Hall was built of sandstone, the walls being 3 ft. 6 in. thick. On this were superimposed heavy transverse arches and the upper walls—all of brickwork. The ground floor had been used for stables and, in consequence, the lower portion of the walls was in a bad state, the mortar being reduced almost to sand, much of which had fallen out, so that in several parts the joints gaped to a depth of 20-30 in. The walls were badly attacked by the vapors and the arches had cracked in several places. Not only was the wall a source of danger, but it was also desired to make a series of large window openings in it. To renovate the structure and make the desired alterations at the same time, it was decided to cut into the masonry a series of dovetailed slots, each 22 in. deep, and to fill these with a series of reinforced concrete buttresses. The required window-openings were then cut between the buttresses and the foundation was strengthened by an additional concrete footing. The face of the building was then covered with concrete so as to give it a finished appearance. The alterations were designed by, and carried out under, the supervision of Architect Bechstein of Bergdorf.—From Beton U. Eisen, Berlin.

Effect of Inundated Sand on Concrete.—The U. S. Bureau of Standards has started an investigation to determine the feasibility of measuring sand for concrete in an inundated condition. With small additions of moisture to sand, the sand "swells," that is, the volume occupied by a given quantity of sand increases, and this increase sometimes reaches an amount as large as 38 per cent of the original volume. Conversely, the quantity of sand in a measure of given size varies greatly with the amount of moisture in the sand. This fact makes it difficult to insure the same proportion between sand and cement in successive batches of concrete because the percentage of moisture in sand varies greatly from time to time. Preliminary investigations have indicated that if the vessel in which the sand is measured contains sufficient water to submerge the sand, the same quantity of sand can be placed in the vessel regardless of the quantity of moisture originally obtained. The investigation is to determine whether the measurement of sand inundated will effect uniformity in the proportioning of sand to cement and consequently uniformity in the strength of the concrete. An affirmative answer to this question would mean the solution of one of the most troublesome problems in the concrete industry.

Index Numbers of Wholesale Prices Jan., 1913, to Aug., 1922

The accompanying tabulation shows the revised index numbers of wholesale prices by groups of commodities as computed by the U. S. Bureau of Labor Statistics. Revised index numbers for each year from 1890 to 1913 are now in preparation by the Bureau, and will be published in this column as soon as they are available.

The group of miscellaneous commodities includes such important articles as leather, cottonseed meal, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, starch, tobacco, Manila hemp, sisal and wood pulp. The commodities, composing the other groups, are as indicated by the titles.

The new index numbers and the following explanations are from Bureau of Labor Statistics, Form 1531:

The weighting of the prices used in constructing the index numbers for the different groups of commodities by the new 1919 census figures of production, instead of the 1909 data used in preceding reports, conforms to the plan contemplated by the Bureau at the inception of its weighted index number system in 1914 of revising the weighting factors every ten years as new census information should become available. All computations have been carried back to 1913 in order to insure comparability of the figures and also to provide a pre-war standard for measuring wholesale price changes.

The following table gives the revised index numbers for the several commodity groups from January, 1913, to the latest month for which complete information is available. For comparison with the new series, the old general index of all commodities is shown in the last column of the table. Publication of the old series was suspended with the April, 1922, figures.

REVISED INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES AND BY MONTHS, 1913 TO 1922 (1913 EQUALS 100).

										All commodities.	
	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	New index.	Old index.
1913	100	100	100	100	100	100	100	100	100	100	100
Jan.	98	99	99	100	107	101	100	100	106	100	100
Feb.	98	98	100	101	105	102	101	100	105	100	100
Mar.	98	98	100	101	105	103	101	100	103	100	99
Apr.	99	98	100	98	104	103	101	100	100	100	98
May	97	97	100	98	103	103	100	100	98	99	98
June	98	99	100	98	101	102	100	100	100	99	100
July	99	101	100	99	98	99	100	100	100	100	100
Aug.	100	102	100	101	98	99	100	100	98	100	101
Sept.	103	103	101	101	98	99	100	100	100	102	102
Oct.	103	102	101	102	97	98	100	101	98	101	101
Nov.	103	103	101	102	94	97	100	100	97	100	101
Dec.	103	101	100	99	89	96	98	100	96	99	99
1914	103	102	98	93	85	92	101	100	95	98	100
Jan.	103	101	99	99	88	93	98	100	94	98	100
Feb.	103	100	99	99	89	94	98	100	96	99	99
Mar.	102	98	99	100	89	94	98	100	98	98	99
Apr.	102	95	99	98	88	93	97	100	98	98	98
May	101	96	99	95	85	93	97	100	99	97	98
June	101	97	99	91	84	93	96	100	95	97	99
July	103	99	99	91	83	92	95	100	93	97	100
Aug.	106	109	99	89	84	93	96	100	94	101	103
Sept.	106	111	97	89	86	92	109	100	96	102	104
Oct.	101	106	96	88	83	90	108	100	92	97	99
Nov.	102	106	94	88	80	88	107	100	91	97	98
Dec.	101	105	94	88	81	88	107	100	96	97	98
1915	104	105	98	88	99	94	134	100	95	101	101
Jan.	104	106	94	87	82	88	108	99	99	98	99
Feb.	105	108	95	86	86	89	116	99	93	99	101
Mar.	104	106	95	84	88	90	118	99	93	99	99
Apr	104	105	96	82	90	90	118	99	93	99	100
May	105	105	96	82	96	93	116	100	93	100	101
June	101	102	96	81	102	93	123	100	93	99	99
July	104	104	96	81	106	94	130	100	94	100	101
Aug	103	102	97	85	103	93	136	100	93	100	100
Sept.	101	99	99	91	104	94	143	100	92	100	99
Oct.	106	102	101	94	105	98	151	100	93	102	101
Nov.	104	106	106	98	110	101	165	100	95	104	103
Dec.	105	108	107	103	122	104	179	101	100	108	106
1916	123	121	127	126	162	120	181	106	121	127	124
Jan.	110	109	110	113	133	110	184	103	110	113	110
Feb.	110	110	114	115	142	113	204	103	105	115	112
Mar.	111	112	117	119	156	118	206	104	108	119	114
Apr.	113	114	118	120	164	120	200	104	110	121	117
May	115	115	120	120	168	121	193	105	114	122	118
June	114	115	122	122	164	120	191	105	120	123	119
July	117	117	125	121	158	120	175	107	120	123	119
Aug.	125	122	128	116	157	120	157	107	121	126	123
Sept.	131	126	130	120	160	121	168	107	124	130	128
Oct.	136	134	137	128	164	124	164	109	132	136	134
Nov.	147	141	147	155	174	126	167	111	139	146	144
Dec.	146	137	154	163	199	132	172	111	147	149	146
1917	190	167	175	169	231	157	202	125	148	177	176
Jan.	152	140	158	171	198	138	173	118	149	163	151
Feb.	157	146	157	178	204	140	173	119	150	157	156
Mar.	166	148	158	174	218	144	181	120	151	162	161
Apr.	184	164	164	164	230	155	186	121	153	173	172
May	196	175	167	178	240	159	194	121	151	183	182
June	195	171	174	183	267	169	195	123	163	185	186
July	196	169	181	176	292	168	205	129	153	188	186
Aug.	202	175	186	167	282	167	211	129	150	180	185
Sept.	202	176	185	160	260	167	223	130	147	187	183
Oct.	207	180	185	153	207	156	231	130	142	183	181
Nov.	212	181	191	161	183	166	223	131	140	183	183
Dec.	207	181	195	163	183	158	228	133	140	182	182
1918	218	188	228	170	187	172	215	153	156	194	196
Jan.	211	182	201	164	183	161	223	137	145	184	185
Feb.	211	183	205	164	184	161	227	138	145	186	186
Mar.	211	179	211	165	184	164	229	140	147	187	187
Apr.	213	181	220	166	184	169	228	144	152	190	190
May	209	180	226	169	185	170	222	146	155	190	190
June	210	180	233	169	184	172	205	152	160	191	193
July	217	185	238	175	189	177	209	159	159	196	198
Aug.	227	189	239	175	190	179	212	161	160	200	202
Sept	234	195	245	176	190	179	210	163	161	204	207
Oct.	225	198	245	176	192	177	211	164	163	202	204
Nov.	225	204	241	179	191	177	209	164	164	203	206
Dec.	227	206	233	179	187	177	194	163	163	202	206
1919	231	207	253	181	162	201	169	184	175	206	212
Jan.	224	203	220	178	175	176	181	167	166	199	203
Feb.	216	194	210	178	170	173	169	165	163	193	197
Mar.	224	199	203	178	163	171	162	164	161	196	201
Apr.	230	205	205	177	153	169	160	167	160	199	203
May	234	210	216	178	153	173	161	168	161	202	207
June	226	204	243	180	154	189	162	180	167	203	207
July	241	210	262	181	160	209	167	183	177	212	218
Aug.	242	214	276	184	162	226	170	188	187	216	226
Sept.	225	205	283	188	161	229	170	190	189	210	220
Oct.	227	205	291	189	162	229	173	194	187	211	223
Nov.	237	210	304	188	164	232	176	217	189	217	230
Dec.	242	220	317	189	168	248	182	222	189	223	238
1920	218	220	295	241	192	264	200	254	196	226	243
Jan.	247	231	339	194	175	274	189	239	194	233	248
Feb.	237	222	346	199	190	293	195	242	197	232	249
Mar.	237	220	344	208	197	297	205	242	200	234	253
Apr.	243	238	336	231	203	300	210	242	206	245	266
May	241	248	328	239	202	293	213	247	208	247	272
June	237	243	314	250	200	275	212	248	205	243	269
July	233	238	300	259	202	269	212	275	203	241	262
Aug.	218	221	286	269	202	265	209	274	199	231	250
Sept.	210	215	266	281	200	255	205	273	195	226	242
Oct.	187	201	245	280	191	240	198	271	188	211	225
Nov.	173	190	226	264	176	215	181	260	179	196	207
Dec.	152	170	215	254	160	204	164	242	166	179	189
1921	124	144	180	199	129	165	136	195	128	147	163
Jan.	143	162	196	247	153	192	153	217	154	170	177
Feb.	133	151	188	225	147	180	149	217	147	160	167
Mar.	127	151	183	212	140	173	143	216	139	155	162
Apr.	117	144	176	205	138	167	135	216	130	148	154
May	118	139	173	200	138	165	134	209	126	145	151
June	114	137	172	191	133	163	133	196	125	142	148
July	119	141	172	186	124	160	129	180	123	141	148
Aug.	123	146	171	184	117	156	129	179	119	142	152
Sept.	124	142	178	181	116	166	131	179	118	141	152
Oct.	124	140	180	189	116	159	131	180	118	142	160
Nov.	121	139	180	197	114	163	129	178	119	141	149
Dec	120	136	180	199	113	158	127	178	121	140	149
1922											
Jan.	122	131	176	195	112	157	124	178	117	138	148
Feb.	131	135	174	191	110	156	123	177	117	141	151
Mar.	130	137	172	191	109	155	125	175	117	142	152
Apr.	129	137	171	194	113	156	124	175	116	143	152
May	132	138	175	216	119	160	122	176	116	148	...
June	131	140	179	225	120	167	122	176	114	150	...
July	135	142	180	254	121	170	121	173	114	155	...
Aug.	131	138	181	271	126	172	122	173	115	155	...

The Fire-Resistance of Concrete

From Concrete and Constructural Engineering, London.

The complete destruction of the contents of a factory building in Berlin in January last is stated to be the first experience of a fire in a large reinforced concrete building in Germany, and the result of the conflagration fully justifies the claims on behalf of the fire-resistance of the material. The building in which the fire occurred was five stories high, of beam-and-girder reinforced-concrete construction, with an area of 255 ft. by 180 ft., and an interior court about 50 ft. by 70 ft. Each of the five floors was open and all were connected by staircases on the interior court. The building was filled with highly-combustible materials. The fire broke out in the basement and rapidly spread over its entire area, breaking through the skylight into the open court, which formed a chimney carrying the flames up to the exposed windows on each floor. These windows were soon broken through and every floor completely gutted of its contents. After the fire it was found that every piece of material that could possibly burn in the building had been consumed, and that only the reinforced concrete structure itself remained. The principal damage to the concrete was the crumbling off of the outer layers of concrete and the exposure of the steel.

Progress of Marine Borer Studies in New York

Great damage by marine borers in San Francisco Harbor during 1919 and 1920 led to the organizing of a local committee to conduct an investigation. Perceiving that a thorough study required co-operation of several branches of science and technology, and that the subject interested owners and engineers of waterfront properties on all coasts of the United States, the San Francisco committee requested the National Research Council to organize a comprehensive investigation. After extended preliminary inquiry, the National Research Council created a small national committee to undertake investigations of the engineering, biological and chemical aspects of the use of wood for piling and other parts of marine structures, the borers which attack wood, means for protecting wood, and substitutes therefor, including Portland cement concrete and metals, provided owners of waterfront properties would supply funds and other assistance.

A committee was organized in New York in March, 1922, to co-operate with the National Research Council for the study of New York Harbor conditions. It was decided that this committee should include in its studies the territory between Atlantic City, N. J., and New London, Conn.

The committee consists of about 40 members with representation from the Engineer and Quartermaster Corps of the Army, the Bureau of Yards and Docks of the Navy and the Lighthouse Service. Several of the departments of the City of New York are also represented, and the Commissioner of Docks is an honorary member. New Jersey is represented by the Director of the Board of Commerce and Navigation. In addition, the committee includes representatives of the engineering departments of the railroads, and several of the leading engineers, biologists and chemists of the city.

The committee sent out 1,100 copies of a questionnaire to the owners of waterfront properties within this territory. This questionnaire was designed to develop information as to previous and present attacks of marine borers, as well as data regarding methods of protection used and the measure of success obtained from these methods. Replies have been received covering some 330 structures. These replies give valuable information and indicate desirable locations for a more intensive study of the problem.

In order to determine the present location of the various species of marine borers, 81 test pieces were placd on structures in the New York territory. Most of these pieces have been inspected by biologists and 60 of them have been replaced by standard pieces on which inspection records will be obtained semi-monthly. By this means it will be possible to determine not only the presence of borers but also their rate of attack and to follow their movements. In addition to test pieces, a biological survey has been undertaken and piles removed from structures have been inspected. Owing to the fact that the ravages of the Teredo type of borers are not readily visible on the surface, it is necessary to cut up the piles in order to make the inspection thorough.

This biological study has shown the presence this summer of Limoria at several locations in Long Island Sound and Jamaica Bay. Live Teredo have been found on the New Jersey coast in a number of places, in Great South Bay and in the following locations in the New York Harbor proper: Sandy Hook, Perth Amboy, Elizabethport, Fort Hamilton, Clifton, S. I., St. George, S. I., and Bayonne.

A number of evidences of previous attacks, some of them many years ago, were reported and discovered in many structures throughout New York Harbor and in North and East rivers.

In order to determine the conditions under which the various borers work, the Board of Estimate and Apportionment of New York City has at 61 locations made 206 determinations of the temperature, salinity and dissolved oxygen content of the water, and recently has been making determinations of hydrogen-ion concentration. To further amplify the work, the committee has recently established six permanent stations at different points in the harbor where these determinations can be made more frequently.

A sub-committee of the New York committee in conjunction with the National Committee, has been collecting and studying records of methods of protection for both old and new structures and will make this information available to all those interested, in the near future.

The plans of the committee for future work provide for a continuance of the biological survey of the harbor to locate additional feci of possible infection and to watch the spread of borers from their present locations; the chemical and biological study of the water conditions will be continued and adjusted to the biological findings. It should then be possible to give warning to owners of structures which seem in danger from borers if they are spreading from their present locations.

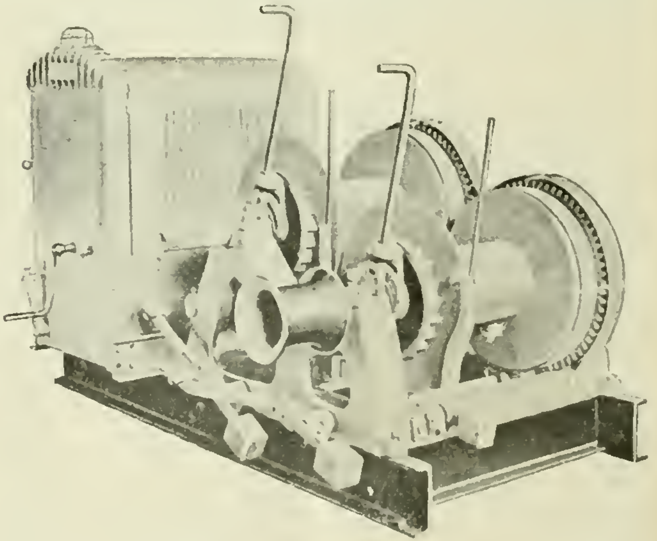
To carry on this study, the members of the committee have done a large amount of gratuitous work, the railroads have contributed funds, material and labor, the City of New York and the States of New York and New Jersey through various departments have contributed labor, materials and boat service, and similar assistance has been furnished by the Army, Navy, Lighthouse Service and Coast Guard. The American Museum of Natural History and the New York Aquarium have furnished working space and scientific assistance.

All these studies carried on by the New York committee are being supplemented by similar work being done at other points on the Atlantic coast as well as in Government and university laboratories. Great assistance is being received from city departments as well as from the scientific departments of the Federal Government and the railroads.

The Chairman of the New York Committee is E. H. Goodrich, and the Secretary is C. L. Gamsby, Room No. 951, 466 Lexington Ave. The Director of the National Committee is Col. Wm. G. Atwood, Engineering Societies Bldg., 29 W. 39th St., New York City.

Hoist with 4-Cylinder Engine

A hoist of simple design, having a 4-cylinder gasoline engine for a power unit, is illustrated below. The engine is the same as used in automobiles and trucks, adapted for the heavier duty of the hoisting machine. It is easily operated and understood, and in case of trouble can be repaired by the garage man. It is easily started and the power is evenly distributed. Every engine is equipped with magneto and governor and reduction gears are encased and run in oil, and are accurately machined and scientifically hardened. The illustration shows the double drum hoist. The manufacturers, the "OK" Clutch and Machinery Co., Columbia, Pa., also make single and double drum hoists, reversible and non-reversible, equipped with multiple engine.



Double Drum Hoist With 4-Cylinder Vertical Gasoline Engine.

Personal

B. F. Jakobsen has established himself as a consulting hydraulic and electrical engineer with office at 321 Rowell Bldg., Fresno, Calif., and will act in a consulting and supervisory capacity, including the preparation of designs, specifications, reports and estimates for irrigation projects, power developments, dams, structures, sub-stations, transmission lines, pumping plants, city water works, industrial power development and electrification. For the past three years he has been designing engineer in charge for the San Joaquin Light & Power Corporation in connection with the Kerckhoff and Kern River power developments. For fifteen years he was an engineer connected with the United States Reclamation Service on the Salt River irrigation project (Roosevelt Dam), Arizona, and the Elephant Butte irrigation project, New Mexico, and with the power developments and electrifications of the Cerro de Pasco Mining Co., Peru, South America, and the Homestake Mining Co., South Dakota.

Roads and Streets Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(h) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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Government by Representatives Versus Government by Experts

The most outstanding improvement in government that has been made in America during the last 20 years is the "city manager plan." This plan is, strictly speaking, not a government by representatives but by experts, and in that fact lies most of the improvement.

Councilmen, aldermen and legislators are representatives of different parts of governmental units. They are therefore partisans and it is significant that they are largely chosen from the profession whose business it is to be partisan, namely, the profession of law. As partisans they seldom look upon any measure from the true economic viewpoint and so do not aim to secure the maximum of economy for the city, state or nation taken as a whole. On the contrary, they seek the greatest economy only for the section or class that they represent.

To visualize the results of such a narrow viewpoint, consider what would be the economic result were a great railway system managed by a congress of railway employes and railway patrons. The representatives of the employes would be constantly struggling to secure higher wages, while the representatives of the patrons would usually be opposing such efforts. Then consider the conflicts between different classes of patrons, each class contending that it should enjoy freight rates lower than the average. Finally, picture the different departments of the railway contesting for larger budgets, regardless of the effect on the total budget.

It needs but little thought to see that a railway corporation governed by a congress of railway workers and railway patrons would be most uneconomically managed; for, instead of applying the criterion of maximum economy for the corporation regarded as a unit, there would be applied the principle of political compromise.

Some of our cities have abandoned the representative form of government, much to their advantage. Our state and federal governments seem also to be slowly adopting government by experts. Note especially the delegation of powers by legislation to commissions of experts, such as the railway and utility commissions. Note, too, the recent act of Congress that gives the President authority to change tariffs. President Harding has rightly called this act the greatest advance in tariff legislation that has occurred since the foundation of the Government, for it opens the way to the employment of a commission of tariff experts who will adjust tariffs from the viewpoint of the welfare of the nation as a whole.

Most civil engineers are employed in public works. They are therefore especially concerned in the type of government that employs them. It is our belief that engineering societies should take a leading part in inducing voters to adopt the city manager form of government and that they should be advocates of government by commissions of experts instead of by legislatures.

Thompson, the Inventor of Pneumatic Tires, Unsung in the Encyclopedias

The wheel has been called the greatest mechanical invention, because machinery, as we have it today, would be non-existent if there were no wheels. Without pneumatic tires we certainly would not have the present great number of road vehicles. Hence it is no exaggeration to call the inventor of the pneumatic tire an inventor of transcendent importance. Yet his biography is to be found neither in the "Brittanica" nor in the "Americana." The life of many a literary Thompson is chronicled in the encyclopedias, but the great engineer, Thompson, has been overlooked.

Seventy-seven years ago, when he was 23 years old, Robert N. Thompson of Scotland took out a patent in which he claimed the invention of "a hollow belt composed of some air and water-tight materials such as caoutchouc or gutta percha and inflating it with air whereby the wheels will, in every part of their revolution, present a cushion of air to the ground or rail or track on which they run."

It is clear that Thompson was the original inventor of the most important development of the wheel since the day when the first great transportation genius fashioned a wheel and axle.

The "Americana" (see Rubber Tires) tries to belittle Thompson's invention, and gives most of the credit to John B. Dunlap, whose pneumatic tire patent was taken out 44 years later, in 1889. It may be admitted that Thompson's invention was not brought into commercial use till the later 80's, without detracting in the slightest degree from his originality. It required the invention of the bicycle (1866) and its subsequent evolution into a small-wheeled vehicle (1884) to create a demand for pneumatic tires. It may be that Dunlop knew nothing of Thompson's patent, but this is unlikely.

In spite of the efforts of hundreds of inventors to substitute metallic springs for the "springy air," Thompson's invention remains unimproved as to its basic idea, namely, a device for presenting "a cushion of air" to the surface on which the wheel runs.

At first the cost of pneumatic tires per mile traveled was very high for heavy vehicles, but gradually the longevity of "pneumatics" has been increased several fold, while the price has been lowered.

If, as now seems probable, even the heaviest of trucks will eventually be mounted on pneumatic tires, the design of pavements will be still further affected by the increasing use of these cushions of air.

Salaries of City Engineers a Disgrace to the Civil Engineering Profession

Even before the World War had brought about a great increase in wages and salaries, civil engineers were complaining bitterly about the relative smallness of their incomes. The cost of living and average wages are now about 65 per cent higher than in 1913. We doubt whether the salaries of city engineers average as much as 30 per cent above what they were in 1913.

Some astonishing conclusions may be drawn from Table I, the salaries there given being taken from a recent issue of the "American City," and rearranged for our purpose:

TABLE 1.—SALARIES OF CITY ENGINEERS.

City.	Population.	Salary.
Cleveland	797,000	$ 483
St. Louis	773,000	667
Boston	748,000	(a)750
Baltimore	734,000	(b)791
Pittsburgh	588,000	500
Los Angeles	577,000	416
San Francisco	508,000	1,250
Buffalo	507,000	583
Milwaukee	457,000	(c)447
Cincinnati	401,000	500
New Orleans	387,000	416
Kansas City	324,000	458
Seattle	315,000	625
Indianapolis	314,000	625
Jersey City	298,000	500
Portland	258,000	417
Providence	238,000	458
Louisville	235,000	333
St. Paul	235,000	417
Oakland	216,000	(a)375
Worcester	180,000	417
Birmingham	178,000	416
Syracuse	172,000	500
Richmond	172,000	625
Memphis	162,000	417
San Antonio	161,000	350
Dayton	153,000	250
Hartford	138,000	500
Grand Rapids	138,000	275
Houston	138,000	(d)416
Paterson	136,000	292
Youngstown	132,000	320
New Bedford	121,000	317
Fall River	120,000	363
Trenton	119,000	275
Salt Lake City	118,000	350
Nashville	118,000	250
Albany	114,000	(e)417
Lowell	113,000	350
Wilmington	110,000	300
Reading	108,000	300
Fort Worth	106,000	250
Kansas City	101,000	250
Duluth	99,000	292
Lawrence	94,000	229
Waterbury	91,000	1,000
St. Joseph	78,000	400
San Diego	75,000	300
Troy	72,000	333
South Bend	71,000	250
Binghamton	67,000	333
Rockford	66,000	208
Brockton	66,000	250
Little Rock	65,000	215
Gary	56,000	333
Lincoln	55,000	333
Haverhill	54,000	192
Kalamazoo	49,000	333
Jackson	48,000	300
Newton	46,000	313
Elmira	45,000	250
Galveston	44,000	(d)200
Pueblo	43,000	207
Lakewood, O.	42,000	416
Fitchburg	41,000	292
Beaumont	40,000	300
Charleston	40,000	283
Auburn	36,000	292
Newport News	36,000	300
Pontiac	34,000	333
Lewiston	32,000	42
Green Bay	31,000	250
Colorado Springs	30,000	350
Asheville	29,000	250
Marion	29,000	200
Mansfield	28,000	200
Nashua	28,000	150
Newark	27,000	150
Wilkinsburg	24,000	210
Spartanburg	23,000	200
Concord	22,000	200
Sandusky	23,000	200
Lafayette	22,000	150
Durham	21,000	300
Beloit	21,000	250
Boise	21,000	169
Oil City	21,000	225
East Liverpool	21,000	208
Eau Claire	21,000	(f)225
Elyria	20,000	250
Parkersburg	20,000	150
Santa Barbara	19,000	225
Duquesne	19,000	292
Manitowoc	18,000	225
Okmulgee	17,000	300
Vallejo	17,000	300
Kewanee	16,000	250
Muscatine	16,000	180
Parsons	16,000	175
Selina	16,000	150
Chillicothe	16,000	125
Naugatuck	15,000	167
Geneva	15,000	275
Jefferson	14,000	(a)250
Keokuk	14,000	165
Huntington	14,000	125
Rochester	14,000	350
Peru	13,000	125
Ambridge	13,000	250
Chambersburg	13,000	150
Reno	12,000	250
Hudson	12,000	150
Bloomington	12,000	83
Oneonta	12,000	209
Emporia	11,000	200
Fairibault	11,000	250
Keene	11,000	200
Johnstown	11,000	150
Eugene	10,000	200
Salem	10,000	80
Chickasha	10,000	100
Provo	10,000	175
Watertown	9,400	225
Chippewa Falls	9,100	167
Chilco	8,900	100
Hanover	8,700	125
Deleware	8,700	188
East Moline	8,700	250
Norfolk	8,600	225
Lock Haven	8,600	125
Iola	8,500	100
Wooster	8,200	150
Alma	7,500	417
Ridgewood	7,500	225
Negaunee	7,400	200
Niles	7,300	200
Orangeburg	7,300	333
Ontario	7,300	(g)275
Rankine	7,300	210
Ypsilanti	7,400	260
Eveleth	7,200	225
Bemidji	7,100	250
New Ulm	6,700	195
Washington	6,300	375
Clareton	6,300	250
Bozeman	6,200	175
Victoria	6,000	250
Palo Alto	5,900	275
Havre	5,400	250
Hastings	5,100	201
Mount Airy	4,800	200
Oberlin	4,200	208
Fort Kent	4,200	300

Foot Notes—(a) automobile furnished by the city; (b) includes $167 allowed for expenses; (c) includes $30 for expenses; (d) "expenses" are paid by the city; (e) "transportation" is paid by the city; (f) plus 60 per cent of income from outside work; (g) including $25 for expense of auto.

The following is a summary of the data given in the table:

No. of cities.	Population.	Average salary.
20	200,000 up	$550
23	100,000 to 200,000	357
30	30,000 to 100,000	304
30	15,000 to 30,000	212
50	4,000 to 15,000	210

This indicates that salaries of city engineers in cities of 15,000 to 30,000 population are substantially the same as in citites of 4,000 to 15,000. It should be noted, however, that a large number of cities smaller than 15,000 pay their city engineers either on a per diem basis or on a percentage basis. The prevalent per diem rate is $10 and the prevalent percentage is 5 per cent.

Let us now consider the property that is designed and maintained under the direction of the city engineer. It consists principally of the streets, sewers and waterworks, whose approximate original cost is about as follows per capita:

Streets	$20
Sewers	30
Waterworks	40
Total	$90

To this may be added about $10 of miscellaneous property, making a total of $100 per capita. Hence in a city of 20,000 people there is about $2,000,000 worth of property for which the city engineer is responsible. Ask any business man whether he would put an engineer in charge of the design and maintenance of a $2,000,000 plant at a salary of only $210 a month. He would consider the question almost an insult to his intelligence; for he knows that he would gladly pay as little as $500 a month for such an engineer for such a plant. Indeed, if he were sufficiently experienced in such matters he would pay fully $10,000 a year to an engineer in charge of a $2,000,000 plant.

It is our belief that if engineering societies take this matter up with city councils and boards of trade, they can persuade most cities at least to double the present salaries of city engineers.

In our next issue we shall outline ways and means of effecting this result.

Engineering Cost of Iowa Highways

The percentage of engineering cost on the primary road system of Iowa in 1921 totaled 5.62, according to the Service Bulletin of the Iowa Highway Commission. This included cost of surveys, making of plans, location and inspection of materials, supervision of construction work and all overhead expenses including an allotted proportion of the expense of the highway commission. Percentage of engineering costs on the township system on the part of both the highway commission and the county engineers was 5.05. Of this percentage, expenditures covering cost of all engineering work done by the county engineers and their assistants was 4.22 of the total amount expended on this system. The percentage of engineering cost due to the maintenance of the state highway commission was .83.

Life of Culvert Pipe

To the Editor: In an editorial entitled "What Is the Life of Corrugated Culvert Pipe" in your Sept. 6 issue, you give the impression that if a culvert pipe will last as long as the pavement under which the culvert is laid, it can be considered as permanent.

It seems to me that the fact that a culvert lasts as long as the pavement is of little importance, in view of the fact that there is no reason why a culvert should be disturbed even when a pavement has worn out and must be replaced. In fact, this is one of the big advantages in using cast iron pipe culverts—namely, that the culvert and embankment need never be disturbed even though several pavements may have been laid and worn out.

I heartily agree with you in the last paragraph, where you say that "the life of corrugated pipe depends mainly upon the chemical character of the metal." The chemical character of corrugated pipes is apt to vary even in the case of pipes made by the same manufacturer. Cast iron pipe, on the other hand, will last for centuries and a variation in the chemical constituents has little effect on the life of the pipe.

It is true there have been some old genuine wrought iron pipes that have lasted for a considerable space of time, but they are the exception rather than the rule, and it is doubtful if modern methods of making wrought iron will produce pipes as good as the few old ones that are known of. On the other hand, except under most unfavorable conditions, cast iron pipe has never failed on account of corrosion, and the first cast iron pipe laid 260 years ago is in service today.

THOMAS F. WOLFE,
Secretary,
Cast Iron Pipe Publicity Bureau.
Chicago, Ill.

Black Base for Heavy Boulevard Traffic

By JOHN B. HITTELL.

Washington Blvd. from Halsted St. to Ogden Ave., Chicago, under the jurisdiction of the West Chicago Park Commissioners, is being repaved with a standard 2-in. sheet asphalt wearing surface upon an asphaltic concrete (black base) foundation. The roadway width is 48 ft. and the length 4,630 ft.; the square yardage approximates 26,000. The Commonwealth Improvement Co. of Chicago, being the lowest bidder, secured the contract.

While nominally a boulevard the layout of the street with its half or staggered intersections is such that heavy traffic will be permitted in going between intersecting outlets. There are 13 streets leading onto the boulevard at intervals of about 330 ft. from which unrestricted traffic will cross over or use the street to the next nearest intersection. Halsted St., the eastern terminus of the improvement is only a mile and a quarter from Lake Michigan and lies at the door of the west side manufacturing district. Within the limits of the improvement the street has long passed the state of a residential boulevard and is fronted by many manufacturing or heavy trucking concerns. Among these may be mentioned the National Biscuit Co., United States Post Office Garage and the Chicago Machinery Exchange. These conditions, the general disturbance of the macadam foundation prior to the present paving operations, and a small increase in elevation of the new surface were among the reasons prompting the Commissioners in selecting a resilient instead of a rigid base for the wearing surface.

The placing of the black base involved no methods of construction differing from those commonly employed in laying binder. Where the depth of it was more than 3½ in. the base was laid in two courses.

Standard Mexican asphalt produced by the Standard Oil Co. of New Jersey is used in the asphaltic concrete base and wearing course, typical analyses of which are as follows:

BASE.

Bitumen	4.9
Passing 200 mesh	2.0
Passing 80 mesh	9.5
Passing 40 mesh	5.6
Passing 10 mesh	3.1
Passing 4 mesh	10.2
Passing ½ mesh	24.6
Passing ¾ mesh	28.4
Passing 1 mesh	11.7

WEARING COURSE.

	%
Bitumen	10.0
Passing 200 mesh	12.3
Passing 80 mesh	29.9
Passing 40 mesh	37.7
Passing 10 mesh	10.1
Pen AC	41

For the West Chicago Park Commissioners, Mr. Wm. G. Barclay, superintendent, has general charge, while Wm. G. Keith, engineer, Thomas Newton, field engineer, and Wm. A. Basse, inspector, are responsible for details of office and construction work. Alexander Todd and Walter Leininger, constituting the Commonwealth Improvement Co., as giving particular attention to the construction, with Wm. G. Foley as foreman in charge.

Walter H. Flood & Co. and the Chicago Paving Laboratory are acting, respectively, as chemical engineers for the contractor and commissioners.

Special "Flivver" Car for Charging Mixer

A rather unusual management for charging the mixer was used by the C. M. Kirkpatrick Co., Indianapolis, on its contract for a section on the National Old Trails road in Hancock County, Indiana. The arrangement is described in Successful Methods from which this note is taken.

This section of highway paralleled an interurban traction line on which the contractor had a gravel pit, and the sand and gravel for the job were hauled from the pit on the electric line in side dump cars which were unloaded directly on the subgrade. Thus alternate piles of sand and gravel were made along one side of the subgrade, leaving the other half open so that the trucks could bring in the cement and stock it on special skids along the opposite shoulder. These skids were fitted with special tarpaulin which protected the cement from exposure. The method of handling the material after it had reached the subgrade was as follows: A section of 24-in. gage track 100 ft. long mounted on 2-in. by 6-in. wooden ties with 2-in by 4-in. wooden stringer along each edge was laid in the center of the subgrade with one end at the mixer skip. At the mixer skip, a 3 ft. section of track was hinged so that it could drop into the mixer skip when down and could be thrown back to allow the skip to be raised. This end of the track was raised about 15-in. above the sub-grade so as to allow the low dump body to come to a position nearly vertical when dumped.

A special charging car was developed by the contractor from a chassis of an old flivver. The original power plant of this flivver, together with the transmission drive shaft and rear axle, were mounted in a new frame set on car wheels. The original rear axle was fitted with sprockets and acted as a jack-shaft having a chain drive to the rear car wheels. On this frame was mounted a very low, broad dump body so bound that it dumped itself when the catch was released. This small charging car ran back and forth on the 100 ft. length of track carrying the material to the mixer skip.

A loader equipped with a measuring hopper loaded, measured and dumped the gravel into the dump body. Three men shoveled the sand into 2 small boxes mounted on a wooden horse standing alongside the track. These boxes were hinged so that they could be dumped easily and quickly into the dump body. The flivver made the round trip, the entire 200 ft., in 1 minute. A single team with a single block moved the track ahead as the mixer was moved. The introduction of the loader saved the wages of 5 men and also speeded up production.

With this system the daily average pour in 10 hours was 834 sq. yd. or 170 cu. yd. This means an average of a batch every 2 min. and 1 sec. A maximum of 1088 sq. yd. was laid in 10 hr. or 222 cu. yd. This is at the rate of 1 batch every 1 minute and 33 seconds.

The concrete pavement is 19 ft. wide, 8-in. thick at the center and 6-in. at the edges.

Ross Cox was in charge for the contractor.

Why the Engineers Lost Their Jobs

We recently heard of a county commissioner in Nebraska who dismissed his engineers because "they did nothing but drive stakes and sight through at them." This reminds us of a timely article in "The Nevada Highway News" which says in part, "There is need of a great deal of educational work among the people of this country. A great many have no clear idea as to what a highway engineer really does and are apt to belittle his work. A clear understanding on the part of the taxpayer of the fact that accurate surveys and careful planning are necessary if the state is to have proper location, alignment, and drainage of its roads and the most economical construction costs, would not only make easier the work of the highway departments in promoting and financing road construction but would also place a greater importance upon the work of the engineer."—From the August Report of the Nebraska State Department of Public Works.

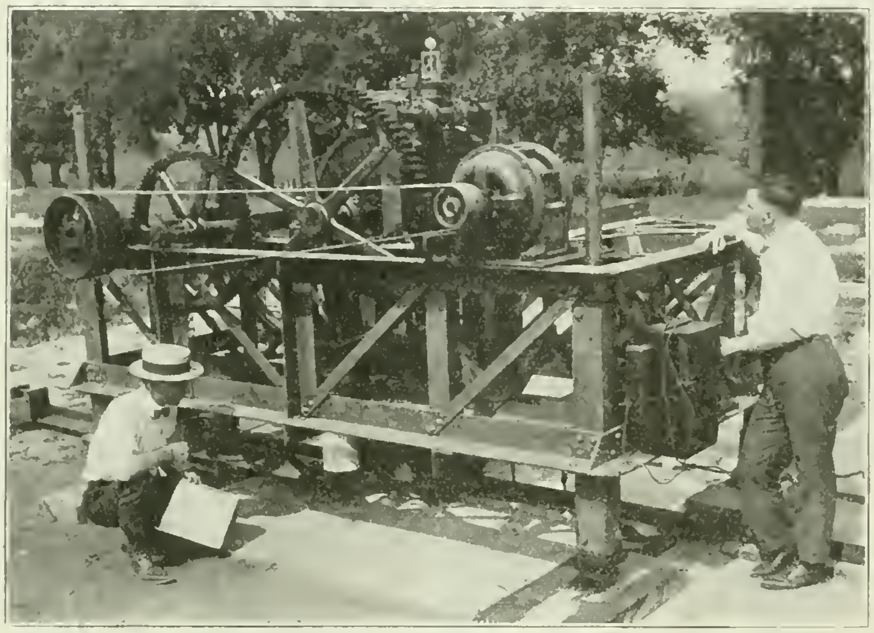
Township Road Expenditures in Iowa.—Based on reports from 1,359 townships out of the 1,606 in the State of Iowa, the average road expenditure in 1921 was $4,153 per township.

Government Road Tests Show Progress

Determining Pavement Wear on Circular Track with New Road Impact Machine

The road research investigations of the Bureau of Public Roads of the United States Department of Agriculture at the Arlington experimental station are now well under way.

New Machine for Testing Road Impact.—A new portable road-impact machine has been received and is giving most satisfactory results in testing the series of road slabs placed earlier in the season. This series consists of 120 concrete slabs ranging from 4 to 10 in. in thickness and from lean to rich mixtures. Some of the slabs are reinforced and others have a 2-in. Topeka top. There are at least two slabs of each type of construction, one on a dry subgrade and another surrounded by ditches, which are kept flooded.



Machine for Testing Road Impact.

Briefly the new machine, which is shown in the illustration, consists of a typical truck wheel with spring and variable load above it, which is raised and allowed to fall on the slab from any desired height by means of an electrically-driven cam. Recording devices measure the deceleration or rate at which the wheel is brought to rest after coming in contact with the slab, the deflection of the slab at a number of points on a line across the slab, settlement of the slab into the subgrade, permanent set of the slab and the maximum instantaneous fibre stress at the point where the blow is struck.

On the first slab tested the various recording devices checked each other with surprising closeness. For a series of blows varying slightly in intensity curves for the fibre stress, deceleration, and deflection showed corresponding variations and gave assurance as to the accuracy of the new methods of measuring. Some interesting information as to the variation of the support offered the slab by the subgrade under a series of varying blows is being secured.

With the information and experience gained from last year's experiments on impact making possible refinements in the new tests it is thought that an analysis of the data when all of the slabs are tested to destruction will throw a great deal of new light on truck impact on rigid pavements.

The circular track for the testing of asphaltic concrete to determine the cause of waving is now about ready for the automatically controlled truck traffic. Twenty-seven sections of asphaltic concrete of various mixtures have been laid on a cement concrete base, the coarse aggregate of the bituminous mixes ranging from 40 to 70 per cent with variations in the grading of the finer material. The amount of asphalt varies from 5.5 to 7.0 per cent and has a penetration value of from 45 to 85.

Track for Wear Test of Concrete.—In line with the Bureau's policy of cheapening the cost of road construction by the use of local material wherever possible a circular track for a wear test on concrete has been completed. Sixty-one sections of concrete have been placed. The aggregates used vary in kind and quality, ranging from hard to soft, and there is variation in the amount of mixing water and time of mixing. In order to eliminate the effect of differences in the subgrade the sections are of reinforced T-beam construction, the slab being 4 ft. wide, 10 in. deep with the T-beam in the middle of the slab. The traffic test on these sections will begin soon and the load on the pavement will be made to represent the rubber tired rear wheel of a 3½ or 5-ton truck moving at a speed of 15 to 20 miles per hour. Specimens of concrete for beam strength and compression tests have been made from each mix and are being cured under the same conditions as the corresponding sections.

Results of this wear test, representing modern traffic conditions, together with the beam strength and compression tests which will be made for this investigation and on a similar set made in connection with the impact investigation and which will serve to tie the two together, will furnish a sound basis for the consideration of suggested changes in specifications for concrete road aggregates.

Constructing Track for Concrete Wear Test. Inner Track Used for Bituminous Test.

Cost of Heating Street Oil at Los Angeles

During the year ending June 30 last, 27,927 bbl. of oil were heated at the oil heating plant of Los Angeles, Calif., and spread on the street. The cost, according to the last annual report of John A. Griffin, City Engineer, was as follows:

	1921-22 Cost per bbl.	1920-21 Cost per bbl.
Oil f. o. b. plant	$2.0782	$2.4337
Plant charges, labor, steam, power and expense	.3453	.5026
Maintenance	.0020	....
Depreciation	.0260	.0282
Interest, 6% per annum	.0324	.0362
Spreading - operation of truck with driver and spreader	.3533	.3735
Administration	.0250	.0220
Total	$2.8622	$3.3962
Total barrels heated (42 gal.)	27,927	25,282

Bituminous Surface-Treated Gravel for Light Traffic Streets

Methods and Cost of Treatment and Experiences in City of 30,000 Given in Paper Presented at 28th Convention of American Society for Municipal Improvements

By D. B. DAVIS,
City Engineer, Richmond, Ind.

Richmond, Ind., has a population of about 30,000. It is laid out in true Quaker style, with rectangular blocks. Its "Main Street," running east and west, is part of the National Road Trail. The wholesale and industrial districts are grouped along the Pennsylvania railroad, leaving three sides of the town devoted to residences. The city occupies four square miles in area and is very closely built up.

Method of Resurfacing.—As there is an abundance of good local gravel, that material was first used in the constructing of its streets some 25 to 35 years ago. The gravel was laid to a depth of 12 in. In the process of time these gravel surfaces required resurfacing, and it was decided to do this with the local gravel from the city's pit. The gravel which was used showed the following screen test:

	Per cent.
Passing 1½-in. screen	100.0
Passing 1½-in. screen, retained on ¾-in. screen	11.7
Passing ¾-in. screen, retained on ½-in. screen	6.7
Passing ½-in. screen, retained on ¼-in. screen	16.9
Passing ¼-in. screen, retained on ⅛-in. screen	17.3
Passing ⅛-in. screen, retained on No. 50 screen	29.4
Passing No. 50 screen	4.7
Clay content	13.3

The clay appears as a coating on the pebbles and not as lumps in the mixture.

This new gravel surfacing was spread to a depth of from 4 in. to 5 in., when it was rolled and waterbound, as in macadam construction. Special care was given to the finishing process of the surface. This was done to more nearly satisfy the abutting residents with the low cost surfacing material. Then in 1919, it was determined to experiment with surface treatments of Tarvia B on these gravel pavements. N. 21st St. and N. 17th St. were the first ones treated. The success attained on these streets resulted in treating others each year.

Surface Treatment.—For successful results it has been our experience that the gravel surface must be firm and comparatively smooth prior to the application of the surface treatment. Better results are obtained if the gravel street is subjected to traffic for a season before applying the surface treatment.

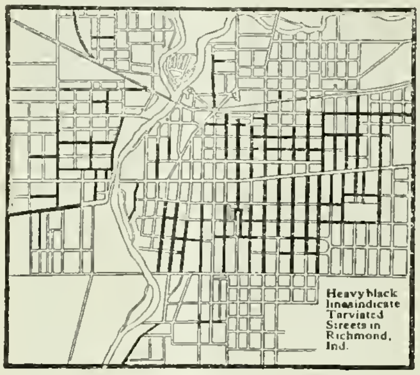
The preparation of the surface consists in repairing all depressions by filling the same with ¾-in. stone, tamped to about 3/16 in. below the street surface and sealing them with hot Tarvia. If there is dust on the surface, it can be removed to the gutter with a rotary sweeper. Otherwise good results have been obtained by applying the bituminous material directly to the gravel.

The Tarvia B was applied cold by means of a pressure distributer. For initial treatment, ⅓ to ½ gal. per square yard was used, with subsequent treatments of ⅓ to ¼ gal. per square yard. Better results are obtained by not applying any covering material whatever in the initial treatments. This allows the bituminous material to be absorbed by the surfacing gravel, which it does to the extent that, after traffic has ironed it out for a time, investigation shows that a crust has been formed of a thickness of from ⅜ to ½ in. Subsequent treatments are covered with a light sprinkling of pea gravel, to the amount of about 5 lb. per square yard.

Cost of Resurfacing and Treatment.—The city street department does the gravel resurfacing and applies the surface treatments with its own forces. The cost of resurfacing with gravel at present prices is approximately as follows:

	Per cu. yd.
Cost of bank-run gravel pit	$0.50
Hauling by teams, 6 loads per day, 1½ yd. per load; team at 65 ct. per hour	0.72
Spreading on street at 40 ct. per hour	0.13
Extra man at pit loading at 40 ct. per hour	0.13
Cost of gravel on the street	$1.48

	Per sq. yd.
Gravel delivered and spread at $1.48.	$0.33
(5-in. finished depth requires 0.22 cu. yd.) Scarifying and rolling..	0.07
	$0.40


Heavy black lines indicate Tarviated Streets in Richmond, Ind.

Layout of Street System of Richmond, Ind.

The cost of the initial treatment of ½ gal. per square yard is as follows:

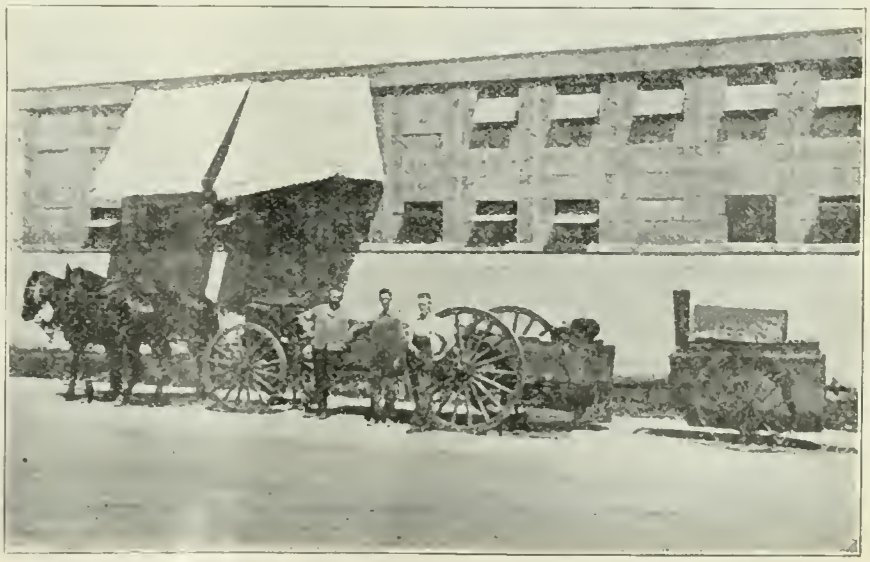
Gravel covering at $1.50 per cu. yd..	$0.005
Binder f. o. b. track at 13 ct. per gal.	0.065
Cleaning and application	0.020
Cost of treatment per sq. yd.	$0.090

The cost of subsequent treatments of ¼ gal. per square yard is, $0.058 per square yard of surface.

Maintenance Methods.—It has been found that after traffic has used the treated gravel street for some months, a few depressions may develop, due either to an excess of dust, or a damp clayey spot on the surface prior to the application of the binder. These places will require looking after. This maintenance work is taken care of here by a maintenance repair gang, consisting of a team hauling a special wagon containing stone and sand, with the necessary tools, and back of which is hauled a tar heating kettle. This wagon was specially constructed for the work, the running gears being from a discarded horse-drawn hook and ladder fire wagon. The wheels are roller bearing, which permits the one team to haul the heavy load. The sand compartment in the rear holds 30 cu. ft. and the stone compartment holds 25 cu. ft. Under the driver's seat is a tank for Tarvia B, to be used for very thin patching. The amount of material carried on the wagon will supply stone and sand enough for pouring 2 bbl. of Tarvia X, which is heated in the kettle at the rear. The kettle has a warming rack which holds an extra barrel, over which is a tight hood. The materials thus carried will supply material for the gang for ½ day without returning to the storehouse.

We have made it a point to keep the surface-treated gravel streets in good repair. This makes the fourth year that we have experimented with Tarvia B on gravel and have secured from that experience somewhat of an idea of the maintenance required to keep them in repair. We have been able to figure an average cost for this type of pavement covering a period of 4 years as follows:

	Per sq. yd.
Cost of gravel resurface	$0.400
Initial treatment of ½ gal.	0.090
Maintenance first year	0.008
Second treatment of ¼ gal.	0.058
Maintenance second year	0.003
Maintenance third year	0.003



Maintenance Repair Outfit for Macadam and Gravel Streets, Richmond, Ind.

Maintenance fourth year	0.003
Interest on investment at 5 per cent	0.100
Total amount spent in 4 years, per sq. yd.	$0.665

This does not include any profit, overhead or wear on tools.

Points That Should Be Observed.—Our four years of experience with surface treated gravel has taught us to observe the following points:

Not to apply the bituminous treatment on a gravel surface which is damp or dusty, as it will not incorporate itself with the pavement and will soon break out.

Be sure to apply the treatment uniformly the full width of the street, otherwise it will ravel at the edges.

To have the surface firm and smooth before applying the binder.

Not to apply the binder on any street which has not an adequate foundation, as the binder will not furnish that.

Not to apply the binder on any street unless the treatments will be kept up when they are needed. It has been found here that ½ gal. per square yard the first year with ½ gal. per square yard the second year, will keep the surface in such shape that no treatments will be necessary for two years. To put one treatment on a gravel street and then leave it alone will make it worse than if no treatments had been applied.

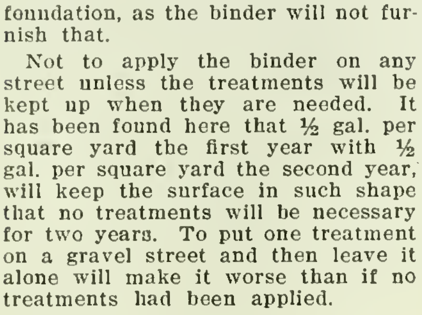
To give the pavements intelligent maintenance.

We have also observed that after the second treatment, the maintenance is no greater than on surface-treated macadam streets.

And that if they are handled rightly, the demand for them on light traffic streets is as much as our forces can conveniently supply.

"Hot Stuff" Shoe Covering

The ingenious arrangement of foot gear shown in the illustration, which is reproduced from the North Carolina Highway Bulletin, was used by laborers to protect their feet from hot asphalt, while engaged in constructing an asphaltic concrete surface on the Rock Mount-Tarboro Road, State Project No. 125. The "overshoes" were made from sections of auto tires.



"Shoes" Made for Section of Auto Tires.

Virginia State Highway Contractors Organize.—Temporary organization of the Virginia State Association of Highway Contractors was effected Sept. 19, when E. Stuart Royer, of Norfolk, was elected temporary chairman. J. A. Addenbrook, of Norfolk; R. B. Allport, of Richmond; J. Colbert, of Fredericksburg, and Mr. Page, of Roanoke, were named on the permanent organization committee.

Weight of Reinforcement for Concrete Pavements

Some interesting information on the weight of steel fabric reinforcement for concrete pavements was given by W. C. Kuhn of the American Steel & Wire Co. in a paper presented at the 1922 convention of the New Jersey Highway Association. The paper is printed in full in the August issue of The Highwayman from which we quote the following:

At the present time, there is a wide variation as to specifications, running from 25 lb. per 100 sq. ft. to 90 lb. per 100 sq. ft. In New York State alone, there were five different weights, i. e.—25, 30, 40, 56 and 60 lb. per 100 sq. ft., the weight called for depending on the conditions to be met on each project. New York this year adopted 63 lb. per 100 sq. ft. as standard.

Pennsylvania State specifications for the past two years have called for 56 lb. per 100 sq. ft., an increase over their previous specifications which called for 25 lbs. per 100 sq. ft. This State is now considering the advisability of increasing the 56 lb. specification, and at this writing have about decided on 65 lb. as standard.

Throughout the New England States the specifications have varied from 25 lb. to 40 lb. per 100 sq. ft., one contract in Bennington, Vt., calling for two lines of reinforcement 28 and 40 lb. respectively, making a total of 68 lb. per 100 sq. ft.

In the South 25 lb. per 100 sq. ft. was the usual specification for the few reinforced concrete highways that were built up to the past year. However, on work advertised during the Fall of 1920 and subsequently, the engineers in Virginia, West Virginia and North Carolina have been specifying for heavier reinforcement, but South Carolina still calls for 25 lb. per 100 sq. ft.

In the middle West the specifications vary from 30 lb. to 55 lb. per 100 sq. ft., Kansas specifying 45 lb. Kentucky 40 lb., Minnesota 50 to 55 lb., Ohio 30 lb. and Arkansas 40 lb.

In New Jersey 34, 45 and 56 lb. per 100 sq. ft. have been specified for single line reinforcement, and on double line reinforcement 34 and 56 lb., making a total of 90 lb. The 34 lb. specifications have been chiefly for county work, and there are many reinforced concrete roads in New Jersey with 34 lb. of steel that are standing up perfectly.

The 45 lb. specification was for the two sections of the Fort Lee Turnpike, across the North Jersey meadows. This heavier fabric was specified to offset the hazards of the soft ground over which the road was constructed. The results seem to have justified the extra steel as one section 3500 ft. long has been down since 1917 and the second section, 1000 ft. long since 1919, and there are only one or two cracks in the entire road. There is a tendency, however, to increase the New Jersey County specifications to 56 lb. per 100 sq. ft. to correspond to the State specifications for single line reinforcement. Judging from the results that have been obtained by the use of 34 lb. material, I do not see the logic of increasing the cost of the road to this extent, especially in view of the fact that practically all county roads are in the secondary system and not subject to the heavy traffic of the main or through routes. On main lines where the thickness of the slab has been increased to 8½ or 10 in. or more, I consider the 56 lb. specifications more justified.

How Pennsylvania Marks Its Detours

During the last three years the State Highway Department of Pennsylvania has developed a system of marking detours which has eliminated for the most part the criticism which occurred in 1919, when the department embarked on its extensive road building program.

The Standard Sign.—Standard signboards are used on every detour in Pennsylvania. These are of wood, so built as to protect the signs from the soaking effect of rains. On the upper portion of the board appears the large word "Detour," a direction arrow and the words "State Highway Department." There are three different standards governing the lower portion of the board. One gives information concerning the terminus of the detour, with notations concerning intermediate points, as: "To Lancaster, Via Columbia and Mountville." A second bears the same information, and below it the further direction, "Road Open for Traffic to Salunga." This means, of course, that while the main highway is closed to Lancaster traffic it is open for traffic going only to Salunga. The third standard contains two-way directions, thus: "To Lancaster, via Columbia," with an arrow pointing in the proper direction, and "To Lebanon, via Cornwall," with a pointing arrow. It is frequently necessary to give direction concerning points in both directions.

Marking of Detour Signs.—The lettering on all detour signs throughout the state is now uniform. Originally blue crayons, or red, were used, and the names of towns and cities were written on white cards. The weather quickly erased these names. The result was confusion. The department has supplied each of its 15 district offices with standard stencils. With a stencil it is not possible to secure a full letter, so that the offices fill in the open spaces, completing the letters as shown in the standards. The resulting sign can be read at a considerable distance; and they are placed so that at night the beams from headlamps will reach them. It is particularly provided by the department that no sign may be placed where it will be beyond the rays from lamps, and the engineering forces before erecting signs cover the roads at night, to be sure the locations are right.

The signs at the beginning of the detour give complete information concerning the terminal points; those within the detour give information concerning the termini, and also local points. The colors used on the entire sign are distinctive not only in daylight, but under lamp rays. The sign approximates 24 by 36 in. and is mounted on a post the height of which depends upon the angle at which the sign is reached by rays from lamps.

Difficult to Keep Signs in Position.—One difficulty encountered by the state's engineers is in keeping detour signs in position. There seems to be at large a great number of vandals who delight in tearing the tin and heavy cardboard signs from the signboards, and throwing them away. Instances have been reported where the entire sign, including the post, has been torn down and carried away. In other instances persons with peculiar ideas of humor have reversed signs in such a way as to give directions exactly opposite of correct. While an effort is made to inspect the signs on each detour daily it is sometimes impossible to do this, and the troubles encountered by travelers who see no signs are directly the result of the work of the vandals or mad wags who are having what they call a "little fun." Some trouble was had for a time with persons who imitated the department's signs for advertising purposes. In an eastern Pennsylvania county a number of roads were placarded at intersections with signs bearing a very large "DETOUR" and the smaller notification that a merchant had a piano sale. The traveler seeing only the larger word was far off the road when he discovered his mistake. This lack of discretion on the part of advertisers resulted in an enactment of a law prohibiting the imitation of a state highway department sign for any purpose.

200 Detours in Use.—At this time (Sept. 7) there are approximately 200 detours on state highways in Pennsylvania, and approximately half a hundred on county or township roads. In several instances there are very rough detours occasioned by work on city streets which bars entrance to a municipality. Not all detours are under the control of the state highway department, by any means. The standardization of detour signs makes it possible for travelers to know whether the detour is occasioned by state work or otherwise.

Maintenance of Detours.—The state highway department is frequently asked why it cannot put its maintenance forces to work on township roads used as detours, so that they will be more travelable. Under the state law this is an impossibility, the department being forbidden so to spend its money. Maintenance of the roads is by the authorities which control them. The department in the majority of contracts for the last two years has secured agreements from counties or townships providing for the upkeep and repair of detour roads by these units, but in some instances the agreements have been ignored after actual use of the roads by detour traffic begins. The public, unacquainted with the facts, criticizes the highway department, which is of course blameless.

One of the worst detours in Pennsylvania since 1919 was that on the Lincoln Highway between Saluvia and Harrisonville, Fulton County. Two side roads were used—one for eastbound and the other for westbound traffic. Both roads were merely earth trails and the heavy traffic soon cut them to pieces. Efforts of the department to secure their improvement were fruitless. Complaints were not only numerous, but very loud.

Paving the Streets of Zion with Concrete

Methods Employed at Zion City, Ill., the Home of the Christian Catholic Apostolic Church, In Paving a 1/2-Mile Section of Its Main Street.

For a number of years the stretch of highway through Zion City has been a thorn in the side of the motoring public. There was an excellent road between Chicago and Milwaukee with the exception of the street in Zion City. The street is known as Elijah Ave. It had an old macadam surface that had become full of pot-holes, and the 1/2 mile was the only uncomfortable stretch on a ride between the two large cities. Although Zion was

When a decision was finally reached to improve the road through Zion City a committee of Zionists visited different sections of the country looking over highway work and picking up the best ideas they could find. From California to Pennsylvania this committee traveled and they not only paid strict attention to highway work, but they assimilated a lot of excellent ideas. Back in Zion City it was decided to pave the road with concrete

Elijah Ave., Zion, Ill., Before Paving.

Institutions and Industries. This is a local organization that has taken prominent part in construction work within the city. However, the men were not acquainted with highway engineering. True, they had had some experience with concrete work, but there was some doubt as to whether they could successfully carry out a job of the size presented by the street contract. The answer is best found in the report of a number founded by John Alexander Dowie it is now under the control of Wilbur Glen Voliva, and—as a large sign informs the passerby—it is a community where Zion people and Zion people only are wanted.

and the contract was let to the Zion of experienced engineers who happened to pass through Zion City a few days ago and stopped off to look the job over. This is what they found.

The present job consists of 19,700 sq. yd. of concrete and 4,200 lin. ft. of integral curb. There will be one block 30 ft. wide on the southern end followed by two blocks 76 ft. wide and one block 50 ft. wide. The adjoining sections are 18 ft. wide and were laid last year by the state of Illinois when concrete was placed at each end of the pavement now under construction.

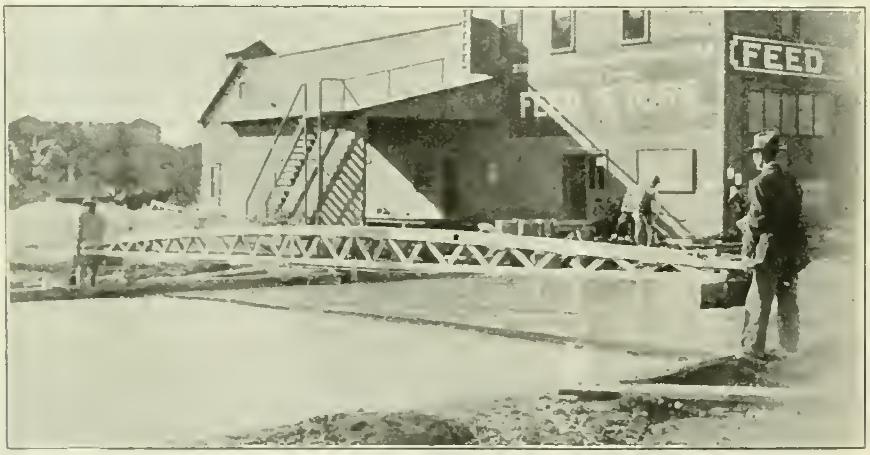
Sand is being hauled to Zion City from Libertyville, Ill., and crushed

Unloading Sand and Stone Into Bins.

limestone from Racine, Wis., in side dump cars. These cars hold 12 to 14 cu. yd. each and as they cannot be used for coal hauling they are not affected by the I. C. C. ruling on open top cars. Two men and a team with driver unload the sand and stone. Because the loading bins are too high to permit the entire load to flow freely from the car when dumped, a scraper, backfiller type, is used to drag the material from car to bins. This is pulled by the team, which also moves the cars one at a time as needed. Four men fill the hoppers below the bins, two or three of them working with stone and one or two with sand. There are four hoppers for stone and three for sand.

Unloading Arrangement at Bins

Trucks are driven alongside the bins under the hoppers in a depressed roadway made by excavating to a depth of about 3½ ft. As the tracks are several feet above ground surface it was possible to arrange this simple but efficient loading plant at a low cost. By pushing a lever the truck driver releases clips that hold up a steel bar on the bottom of the hopper, which then swings downward on center pivots and quickly dumps. A man in the pit pushes the hopper up again. Enough sand for a 4-sack batch of 1:2:3 concrete is first taken on and then the stone. Cement is emptied from sacks upon the aggregate near the mixer; it is hauled from cars to subgrade on wagons. Two men are needed to empty sacks and two are required at the car. Cement could not be secured over the Chicago North Shore & Milwaukee or it would have been added at the loading plant.



Light Wooden Bridge of 40 Ft. of Span.

Eight Ford trucks with rectangular Lee dump bodies make up the hauling equipment. This type of body was selected instead of the V-shaped body because it required less clearance under the hoppers. The trucks are driven on a steel turntable near the mixer, and are turned so that they can back up to the mixer with the load.

The pavement in Zion City is of a uniform section 8½ in. thick. Joints are spaced 30 ft. apart. Reinforcing weighs 44 lb. per 100 sq. ft. It consists of Truscon wire mesh and is placed 3 in. below the surface. Half of the pavement is being placed at a time, while the curb is being constructed, integrally with the pavement.

Concrete is luted to the proper contour. Four longitudinal lines of heavy steel pins are set in placing the 39-ft. slab. These pins are spaced about 5 ft. apart. The end of each pin has been bent over to form a semi-circle and the pins are driven down until these ends are at the proper surface elevations. A feature of the finishing equipment is a light wooden bridge of 40-ft. span. Most bridges of much less span are heavy, but by care in bracing a rigid bridge was secured that is easily moved by two men. When the first half-width of slab is placed, half of a 3-in. strip is nailed along the center of the form. This forms a V-shaped indentation that will be filled with concrete when the second half-width slab is placed, and should decrease the chances of one slab moving above the other along the center joint.

The entire construction job was planned by the Zion Institution and Industries, and the contractors who recently visited the work declare that it is one of the best pieces of paving in the state. Although the men doing the work are not experienced highway contractors, they took advantage of the service rendered by the engineers of the Portland Cement Association and much valuable information was secured in this manner.

There has been some difficulty in securing cement for the job on account of the coal shortage interfering with cement production, but it is expected that the road through Zion City will be open to traffic by the middle of October.

The Average User's Criterion of a Good Road

In the mind of the average user of the highways, a road is only as good as its riding surface is smooth. The foundation of the road may be the most solid and substantial it is possible to build, with grades and drainage carefully taken care of, but if the riding surface be rough and uneven the road is at once classed by the general user as a poor road. This is true whether the road is earth surfaced, graveled or paved. Smooth up an earth road with a road drag and the user at once declares it to be a good road, and it is from his standpoint, which for the immediate time is, the ability to go over the road speedily and comfortably, without unpleasant jarring and jolting. The user of the road, as a general proposition, is the man to whom any new highway proposition must be sold. If he does not like the road surface of the one already built for him, if it jars and jolts him, he will not be inclined to buy the new one. The road user holds the road officials responsible for a bad bargain in road building just as much as the purchaser holds any other manufacturer or builder responsible for a bad bargain in any other type of construction. He will not be inclined to buy more of the same kind from the same builder. The key to the road builder, if he wants to hold his job and satisfy the people for which he is working, is to put a smooth riding surface on every road he builds and keep it there by persistent and consistent maintenance.—From the Service Bulletin of the Iowa Highway Commission.

Traffic Capacity and Width of Highways

Relation Between the Two Discussed in First Progress Report of Committee Submitted at Last Annual Meeting of the National Highway Traffic Association

By H. C. SMITH.
Professor, University of Michigan.

There has been a large quantity of statistical data compiled throughout the country in the nature of traffic census and many traffic studies have been made to determine the future traffic for given highways. Most of such data are not of maximum value, however, in determining the desirable width of roadways for a given traffic, inasmuch as the variation in speeds of various classes of vehicles generally is not given consideration.

Any computation of required width of roadway based upon the assumption that all the traffic on a given highway outside of a municipality will travel at a common speed should be used with great reserve, as the assumption is obviously incorrect in all but exceptional cases.

Two Lane Highways.—For the greater part, highways outside of municipalities need have but two lanes of traffic to care for the traffic which they are called upon to accommodate. Highways leading into large municipalities or connecting nearby cities, however, present a problem that calls for careful solution inasmuch as they may, and often do, carry traffic that varies in speed from about 3 miles per hour to 35 miles per hour.

In many cases the quantity of traffic approaches, and often exceeds, the economical traffic capacity of a two-lane roadway, although computations may show that the amount of traffic anticipated from traffic surveys could be carried adequately by a two-lane roadway if the traffic is assumed to travel at a common uniform and properly selected speed.

In cases of highways which are to carry congested traffic, the designing engineer must give careful consideration to all functions of a roadway; which should affect his decision in choosing the number of lanes of traffic to be required and the modification of widths of roadways and shoulders for any given number of lanes.

Relation of Functions of Roadway to Its Design.—The functions of a roadway which thus affect the design of its width are enumerated as follows:

1. To provide a sufficient number of lanes to carry the traffic that comes upon it.
2. To provide means of allowing fast moving vehicles to pass vehicles moving more slowly, the speeds being within legal and operating limits.
3. To provide for the ranking of vehicles at the roadside in such cases as for necessary temporary repairs.
4. To be of such a width as to discourage the taking of dangerous chances by operators of vehicles.

When a two-lane roadway has become so congested that it is impossible to operate a vehicle without conerable loss of time due to traffic delay, its economic traffic capacity has been exceeded. This degree of congestion occurs for a traffic count of a great deal less than that equal to the computed traffic capacity of the roadway when variation in speed is not considered.

As the amount of traffic or speed variations increase, the possibility of passing a slowly moving vehicle when it is overtaken becomes less. Ultimately, it becomes entirely impossible for vehicles to pass each other and all traffic must assume the speed of the slowest moving vehicle.

Relation Between Traffic and Roadway Widths.—To emphasize the relation that should exist between traffic and roadway widths, the results of office computations and field observations of traffic operation made by the chairman of the committee may be of interest.

For one typical series of investigations for a two-lane roadway, a traffic of 750 vehicles per hour was assumed, 500 of which traveled in one direction, the remainder traveling in opposite direction. Three assumptions as to variation in speeds were made.

First: 3 per cent were assumed to travel at 3 miles per hour, 10 per cent at 10 miles per hour, 57 per cent at 20 miles per hour and 30 per cent at 30 miles per hour.

Second: 13 per cent were assumed to travel at 10 miles per hour, 57 per cent at 20 miles per hour and 30 per cent at 30 miles per hour.

Third: 13 per cent were assumed to travel at 10 miles per hour and 87 per cent at 20 miles per hour.

It was found under the first assumption that the meeting of two of the 3-mile-per-hour vehicles slowed down traffic each way along the road for a distance of one-quarter mile. The meeting of vehicles of various faster speeds affected the movement of traffic similarly but to a less degree. It was also evident that 750 vehicles per hour, two-thirds of which are traveling in one direction and under the first outlined assumption as to variation in speeds, could not be operated on a two-lane roadway.

Under the second assumption of speeds, the meeting of two slow vehicles affected the traffic for a distance each way along the road of 300 ft., and the operation of the traffic under this assumption was entirely possible.

Under the third assumption the traffic was shown to operate smoothly and the quantity could have been considerably increased.

Effect of Speed on Traffic Capacity.—The results of these computations were checked by observing the operation of traffic on roadways leading into Detroit, and the observed effect of varying speeds checked the calculations quite closely.

The foregoing results should be compared with computations based upon the assumption that all vehicles will travel at a common speed. Under logical assumptions as to clearance between vehicles, and assuming that all vehicles will travel 15 miles per hour, a two-lane roadway should carry about 2,600 vehicles per hour in each direction. If the speed is reduced to 3 miles per hour by a few heavy horse-drawn vehicles the capacity is reduced to about 750 vehicles per hour in each direction. There can be no doubt, therefore, that the variation in speeds affects the traffic capacity and hence the required width of a roadway.

Quite obviously, a stalled car which, through inadequacy of shoulder design of the roadway, is prevented from pulling to one side and hence blocks one lane of traffic, has the same or a worse effect on the traffic capacity of a roadway than a slowly moving vehicle. The roadway traffic capacity can be materially increased by adequate width and design of shoulders.

The safety of traffic should not be disregarded in the design of roadway widths. In the case of two or four-lane roadway, every vehicle operator realizes just when he has the right of way and when he has not. The operation of a three-lane roadway, however, is not so simple. The center lane is not and cannot be reserved for traffic in either direction, so it must be left to each individual operator to decide whether he is more entitled to this lane than another operator going in the opposite direction. Such a width of design fosters danger to traffic.

Conclusions of Committee.—The committee respectfully submits the following tentative conclusions for consideration:

1. The design of roadway widths must give consideration to the economically desirable variation in speeds of the various classes of traffic.
2. Any two-lane roadway carrying intensive traffic should have a width of 20 ft. and should have 5-ft. shoulders capable of sustaining standing vehicles for temporary delays.
3. A two-lane roadway should be increased to a four-lane roadway when the traffic is reduced to the speed of the slower vehicles through not being able to pass, if the economic loss of time will justify the expense.
4. The building of three-lane roadways should be discouraged due to the danger to the traveling public.

Cost of Asphalt Repairs at Los Angeles

During the year ending June 30 last the maintenance of paved streets of Los Angeles, Calif., was handled by a force consisting of one superintendent, four foremen, five roller engineers, 11 asphalt workers, 24 laborers and 1 fireman. Nine 5-ton and one 2-ton trucks were used in the work. The force was divided into four groups. The following table from the annual report of John A. Griffin, City Engineer, shows the cost of the asphalt work:

	Sq. ft.	Per sq. ft
Lutz heater	....	$0.072
Patch work	261.325	0873
Cover work	343.169	.0832
Resurfacing	549.805	.0608

Occupations of Purdue Engineering Graduates.—A recent survey of the graduates in the 1921 class of Purdue University showed the following occupational distribution:

Manufacturing	35.7
Power and public utilities	20.5
Teaching	14.3
Government and state	14.3
Sales	5.3
Railroad	3.6
General	3.6
Building	2.7

Road Expenditures in Iowa.—Iowa, during 1921, spent for road and bridge building on her 104,082 miles of public highway, $38,741,627.

Removing Earth Covering from New Concrete

Road Grader Handled by Motor Truck Proves Economical Method on Pennsylvania Highway Contract

By W. E. VOORHEES.

Concrete Highway Partially Covered with Earth.

In these days of involved specifications and keen competition, every road building contractor will agree that any new scheme or plan of handling a certain situation in highway construction which has for its end the elimination of hand labor, and the surface must be covered with some material so that the fresh concrete will not be exposed to sun and storms to the end that it will dry out evenly and set properly from top to bottom. The usual practice at the present time is to cover the concrete with consequent saving of time and money, is worthy of investigation. With this idea in mind, I will endeavor to describe a new method of removing the earth covering from newly-laid concrete which was recently brought to my attention.

Immediately upon the completion of a section of concrete highway, the loose earth to the depth of about 2 in. This earth covering is thoroughly sprinkled at certain intervals and, at the expiration of about 10 days, it must be removed.

Now, the removal of 2 in. of more or less tightly packed earth from a road surface 18 ft. wide, or more, and from a half to several miles in length, is a job of considerable magnitude. Formerly this work was done by hand labor and, if I am not mistaken, this method still prevails with most contractors. Gangs of men shovel the earth from the roadway into dump wagons or trucks to be hauled to some distant point. Quite recently some far-sighted contractor conceived the idea that this work could be done easily, quickly, and economically by the use of a road grader. A machine was placed on the job and the results were all and more than the contractor had expected. The grader was attached to a motor truck and the earth was pushed into windrows at either side of the highway. It was found that much of this material could be used in leveling up the sides of the roadway next to the concrete, and the balance was hauled away. In a very short space of time long stretches of concrete roadway were cleared of the earth covering.

The illustrations shown in connection with this article will indicate very clearly just what can be accomplished with a road grader in the work of removing dirt from concrete highways. The pictures were taken while the work of removing the earth covering was progressing on a piece of concrete highway recently built in southeastern Pennsylvania. This particular job is a part of route 131, Pennsylvania State Highway, between Philadelphia and Baltimore. In less than half a day the dirt covering was removed by means of a road grader drawn with a G. M. C. truck from a piece of road 24 ft. wide and ½ mile in length. It is needless to say that the cost was insignificant.

Road Grader Removing Earth Covering from New Concrete Highway.

10,620,000 Motor Vehicles in U. S. on July 1.

That the business of the Nation is turning more and more to highway transportation is indicated by statistics on motor vehicle registration as of July 1, compiled by the Bureau of Public Roads of the United States Department of Agriculture. Registration of passenger cars, taxis, busses, and motor trucks totaled 10,620,471 on this date, an increase of 157,176, which is a healthy growth, as the first half of the year is the off season for registration of new vehicles.

The surprising fact, however, is that of the 157,174 increase in registration, motor trucks constituted 116,701, against 35,030 passenger cars and 5,443 taxis and busses. This means an increase of over 16 per cent of the number of motor trucks at the beginning of the year. Figures are not available to show what part of the increase of 5,443, or nearly 11 per cent, in the taxi and bus registration is due to the increase in the number of busses traversing rural and suburban routes, but it is very probable that a considerable part of the increase is due to the development of this new form of transportation

It has been frequently said that the traffic is always ready and waiting when good roads are built, and that the commercial vehicle as a class is more handicapped by lack of good roads than the pleasure vehicle. The increase in the registration of commercial vehicles, coupled with the present activity in highway construction, seems to bear out this statement in the opinion of department officials.

The tables of statistics issued by the bureau shows a registration of 9,467,874 private cars, 55,990 taxis and busses, and 1,096,605 motor trucks, making a total of 10,620,471.

Portable Air Compressor in Road Maintenance

A portable air compressor forms an important part of the outfit used by Monongahelia County, West Virginia, in their maintenance of its concrete road. Compressed air has been found very effective in cleaning cracks and the steel punching nozzle used is excellent for loosening any scale or hardened dirt. The compressor was made by Chris D. Schramm & Son, and is operated by a 6 Hp. gasoline engine. The diameter of the high pressure air cylinder is 5¾-in. and its stroke 7 in. Fifty feet of ¾-in. hose afford a good working raidus for the nozzle. As the mileage to be maintained has been comparatively small, the compressor has been mounted on low steel trucks and is pulled by hand.

Cost of Feeding Horses

The average cost of feed in 1921 for the horses of the Street Cleaning Department of Cincinnati, O., was 39.3 ct. per horse per day. The average consumption of feed per horse-day was as follows:

Hay	16.1 lb.
Oats	12.7 lb.
Nutria	1 lb.

Design of Streets to Fit Traffic Requirements

Considerations Determining Proper Widths of Roadway Outlined in Paper Presented Before the Engineers' Society of Western Pennsylvania

By WINTERS HAYDOCK,
Chief Engineer, Citizens' Committee on City Plan of Pittsburgh.

It has taken engineers a long time to realize that in designing a street, a plan should be worked out by the designer to show how the space within that street is to be utilized, or that there should be a relationship between the dimensions of the street and the objects which are to occupy it. The width of the roadway was generally determined without regard to the position or arrangement of the vehicles upon it. It was apparently assumed that to add a percentage to the width of the roadway would add a like percentage to its capacity or value.

St. Louis Rule for Street Widths.—For example, there was for years in the city of St. Louis a well recognized though unofficial rule that the sidewalks should occupy 40 per cent of the width of a street and the roadway 60 per cent. According to this rule a 60-ft. street would have a roadway of 36 ft., and a 70-ft. street a roadway of 42 ft. Apparently it did not occur to the engineers responsible for this rule that the 42-ft. roadway could accommodate no more traffic than the 36-ft. roadway and therefore was no better than the latter though more expensive to build and to maintain.

Engineers have apparently been slow to realize that the real measure of a street's utility is the number of vehicles which can safely and comfortably be passed over that street at the rate of speed which is proper for the particular kind of traffic which it is intended to carry. They have been slow to acquire the habit of thinking of roadway widths in terms of the number of lines of travel rather than in terms of feet.

Width Varies with Nature and Speed of Traffic.—Although it is easy to see that the capacity of a street can be measured by the number of vehicles which can move upon it simultaneously, it is not so easy to decide how much width should be allotted to each vehicle. The fact is that this proper width will vary somewhat according to the nature and speed of the traffic which the street is intended to accommodate. In former years it was generally assumed that 8 ft. was a proper width for each line of vehicles, but at present it is generally believed that this width is insufficient to permit of comfortable driving at a reasonable rate of speed. Nine feet is now generally considered to be the minimum width which should be provided for each line of moving vehicles. For high-speed thoroughfares 10 ft. would be a better width. If it is expected that the space along the curbs will be used by standing vehicles and will never be used by vehicles moving at a considerable rate of speed, an allowance of 8 ft. for these outer strips will be sufficient; but, as it is only in certain limited localities that it can be assumed that these outer strips will not be used by vehicles moving at the normal speed, it would be better, wherever possible, to allow the full 9 ft. to each line. In making its recommendations the Citizens' Committee has adopted roadway widths as indicated in Fig. 1.

Examples of Improper Street Design.—The failure on the part of engineers to give proper thought to the way in which the space in a street is to be used, frequently results either in a waste of money, an impairment of safety, or a constriction of capacity, or in all three of these. Frequently a few feet of roadway more or less, or a different arrangement of street car tracks, would save the day. Take, for example, a hypothetical case of a roadway 45 ft. wide with two street car tracks in the middle (Fig. 2, Case A). It is too narrow to accommodate safely three lines of vehicle in each direction, even if one of them is stationary. It is no better as a thoroughfare than if it had a roadway but 36 ft.

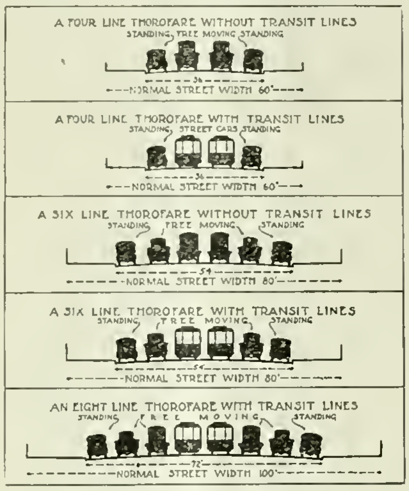


Fig. 1.—Proposed Roadway Widths.

Again, take the case of a street with a 36-ft. roadway and a single street car track placed in the middle (Fig. 2, Case B). As the direction of the street cars is necessarily contrary to that of one of the two lanes of travel which must be partially upon the track, the character of the street as a four-line thoroughfare is destroyed and there is in addition a serious element of danger added.

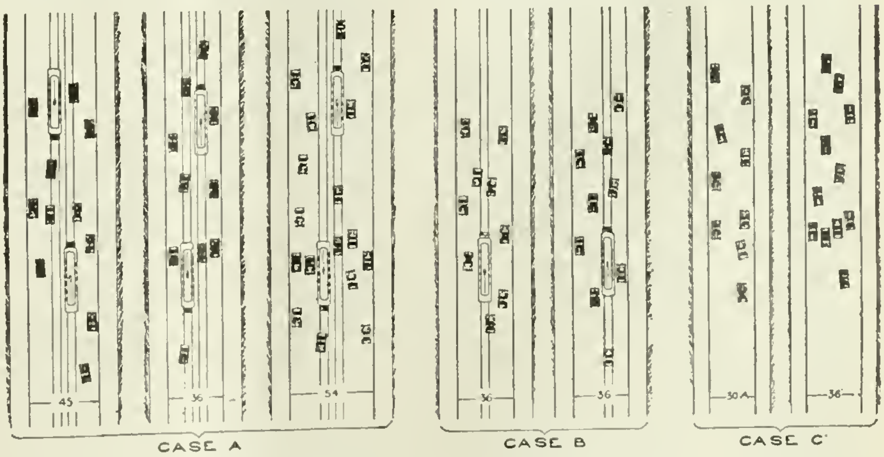


Fig. 2.—Examples of Improper Street Design.

Again, take the hypothetical case of a long bridge which is, we will say, a link in a boulevard system which is expected to have a very heavy Sunday or evening traffic of equal intensity in each direction (Fig. 2, Case C). The bridge has a roadway of, say, 30 ft. This is too narrow for more than three vehicles to move abreast with safety. As the traffic is about equal to each direction, there will be a constant scramble on the part of drivers moving in opposite directions to make use of that odd line of travel, resulting in a very definite element of danger, as well as in irritation and inconvenience to the users of the boulevard. In this hypothetical case the addition of 6 ft. to the roadway would have saved the day by permitting of two freely moving lines of vehicles in each direction. These are only typical illustrations of errors in street design such as have been and are still being made in every city in the country.

Traffic Control for Increasing Street Capacity.—In considering the proper design for streets to insure a full measure of traffic capacity, the matter of the proper regulation of traffic within those streets should not be overlooked. The full possibilities of traffic control as a method of increasing the capacity of very congested thoroughfares have not yet been developed. For example, only a few experiments have been made as yet in the demarcation of lines of travel by visible means in order to prevent vehicles from using a much greater portion of the roadway than necessary, except when passing more slowly moving vehicles. There would seem to be some promise in this idea, and it is certainly worthy of further experimentation.

The whole complicated problem of the rapidly increasing street traffic of our cities is fundamentally the problem of the engineer. It is up to him to use his imagination and ingenuity to the end that very serious conditions in the future shall be avoided.

Charges for Street Replacing at Los Angeles

A special department under the direction of the city engineer's office at Los Angeles repairs all holes and trenches cut in streets for the construction or maintenance of underground pipes or conduits and bills the work against the firm or person to whom the permit for the cut was issued. The charges for all replacement work performed are as follows:

Asphalt pavement—Base and surface, per sq. ft.	$0.40
Macadam pavement, per sq. ft.	.30

Physical Properties of Subgrade Materials

Complete Revised Procedure for Testing and Conclusions from Data Obtained from the Tests Given in Paper Presented June 27 at Annual Meeting of American Society for Testing Materials

BY J. R. BOYD
U. S. Bureau of Public Roads,
Washington, D. C.

During the past year it has seemed inadvisable in some instances to materially change the methods of testing, consequently the complete revised procedure will be presented in this paper. An attempt will also be made to correlate the data so far obtained and to draw any general conclusions which may seem warranted.

Procedure for Testing Materials.—Preparation of Soil Samples.—The sample as received from the field is broken up in a mortar by means of a rubber-covered pestle, care being taken not to break any of the rock fragments, and passed through a ¼-in. screen. That portion of the sample which passes the ¼-in screen is pulverized by passing between rubber rolls, such as those on a clothes wringer, and is then passed through a 10-mesh sieve. Only that portion of the sample which passes through a 10-mesh sieve is used in making the following tests.

Mechanical Analysis. — By the method of quartering, a sample weighing approximately 25 gr. is selected from the soil prepared as described above. This sample is then dried in an oven to constant weight at a temperature not exceeding 100 deg. C. and is allowed to cool in a dessicator. The cooled sample is then weighed and placed in a beaker with approximately 500 cc. of distilled water. This mixture is gradually brought up to the boiling point during a period of one hour and is allowed to simmer for an additional hour. After standing until cool, the material in the beaker is thoroughly brushed and dispersed with a stiff brush for 2 or 3 minutes and then allowed to stand for 8 minutes. The supernatant liquid is then decanted into a vessel having a capacity of about 10 liters. About 500 cc. of ammoniated water (concentration 1 : 500) is then added to the material remaining in the beaker and the brushing repeated as before. After again standing for 8 minutes, the supernatant liquid is decanted into the large vessel. This process is repeated until the supernatant liquid becomes clear after 8 minutes sedimentation. The sand and silt have now been separated from the clay and suspension clay, which are contained in the large vessel. The material in the beaker is transferred to an evaporating dish and dried to constant weight at a temperature not to exceed 100 deg. C. (212 deg. Fah.), cooled, and a mechanical analysis made, using the 20-mesh, 50-mesh, 100-mesh, and 200-mesh sieves. The material retained on each sieve is recorded as percentage of the original sample, and that which passes the 200-mesh sieve is recorded as the percentage of silt in the original sample.

The volume of the liquid in the large vessel is now brought up to at least 10 liters by the addition of ammoniated water, and the vessel thoroughly shaken until all material is in suspension. Seventy cubic centimeters of the liquid are then siphoned from this vessel at a depth of about one-half the total depth of the liquid, into each of four centrifuge tubes. These tubes are then mounted in the centrifuge and run for one-half hour at a speed which for diameter of the head used will exert a centrifugal force approximately 500 times the force of gravity. The material which has been thrown out of the liquid by centrifuging is classified as clay and that which remains in suspension as suspension clay. The solution containing the suspension clay is determined. The clay remaining in the tube is also dried and weighed.

The weight of suspension clay is found from the liquid in four tubes of 280 cc., consequently this weight must be multiplied by the factor obtained by dividing the total volume used by 280 cc. in order to obtain the total suspension clay in the original sample. The weight of clay is determined from the clay in one tube or 70 cc., therefore the total volume divided by 70 cc. gives the factor by which this weight should be multiplied to give the total clay in the original sample. The total weights of clay and suspension clay thus obtained are converted into percentages of the original sample.

The determination of the percentage of suspension clay by this method will include any water-soluble material present which may be determined separately if desirable.

Water-Holding Capacity of Soil.—The water holding capacity of a soil may be considered as the maximum percentage of water which it is capable of retaining. The test for it is made in the laboratory in the following manner: A sample of the soil which has been prepared as described above is placed in a brass cylindrical box 1 cm. high and 5.5 cm. in diameter. The bottom of the box is perforated with 150 holes each 1/32 in diameter. The top of the soil is then struck off by means of a fine silk thread, and after weighing is placed in a pan of water on a brass triangle, and submerged 5 mm. below the surface of the water for one hour. The surface water on the container only is then blotted off and the sample immediately weighed. The water-holding capacity is determined on the basis of dry soil.

Moisture Equivalent.—The "moisture equivalent" of a soil has been defined by Briggs and McLane as the percentage of moisture which is retained by a soil when it is subjected to a centrifugal force equal to 1,000 times the force of gravity. The test is made as follows: A 5-gr. sample of soil, prepared as described above, is placed in a Gooch crucible and allowed to take up water by capillarity until saturated. It is then placed in the damp closet and allowed to stand over night to insure even distribution of the moisture. The crucible is then placed in a Babcock cup containing a rubber stopper to serve as a cushion and provided with a hole sufficiently large to hold the water thrown out during centrifuging. The cup is provided with a brass cup to prevent evaporation. The sample is centrifuged for one hour at a speed which for the diameter of head used, will exert a centrifugal force approximately 1,000 times the force of gravity. Moisture equivalents are obtained by weighing the soil after centrifuging and then drying to constant weight and weighing again. The moisture equivalent is the percentage of moisture, based on the dry weight of the soil, which is retained after centrifuging.

Vertical Capillarity.—This determination is made for the purpose of ascertaining the average percentage of water which will be lifted a distance of 20 cm. in a column of dry soil 25 mm. in diameter. It is of value for comparative purposes only and does not necessarily bear any relation either to the total capillary lift of the soil or the maximum percentage of water which it is capable of holding by capillary attraction. A sample of the soil prepared as described is poured loosely into a 25-mm. glass tube and the tube is jarred until a height of 20 cm. has been reached and no further settlement takes place. A piece of cheese cloth is fastened to the lower end of the tube to hold the soil in place. The lower end of the tube is then just immersed in water. When capillary water reaches the top of the soil column, the tube is weighed and the amount of water taken up by capillarity thus determined. The weight, expressed as the percentage of the dry weight of the soil, may be considered as the average, percentage of moisture which will be taken up by capillarity under these conditions.

Volumetric Change.—A sample of the soil passing a 10-mesh sieve is mixed with a given quantity of water and placed in a small flat cylindrical porcelain dish approximately 6 cm. in diameter and 1 cm. high, struck off level with a small trowel and weighed. The sample is then allowed to air dry and is weighed at frequent intervals until no further loss in weight is recorded. The percentage of final volume in terms of the original volume is determined by filling with mercury the pan containing the dried soil sample. Knowing the volume of the pan and the volume of the mercury required to fill it after contraction of the soil has taken place, the percentage of contraction may be calculated. The volume of mercury in the container is controlled by means of a glass plate which is pressed down firmly over the top of the pan, thus squeezing out the excess.

Comparative Bearing Value.—When determining the comparative bearing value of soils, the soil is prepared for testing by mixing the desired amount of water with the soil by hand. That is, the mixture is kneaded thoroughly for several minutes in order that complete distribution of the moisture may be obtained. The mixture is then covered with a pan and allowed to stand for about 15 minutes, after which it is subjected to an initial load of 10 lb. per sq. in. to insure uniformity of compaction. Having applied the static load and having placed the 1-sq.-in. bearing block upon the soil the container is raised by means of the adjusting screw until the horizontal beam has been carried vertically

0.1 in. The sand for applying the load is now released and simultaneous readings of load and penetration are made for 0.1-lb. increments, the maximum penetration used being 0.2 in. As the point of equilibrium of the system corresponds to a dial reading of zero, the beam is displaced 0.1 in. above the true horizontal position at the beginning of the test and 0.1 in. below at the end of the test. It has been found that the error introduced owing to this condition is negligible. Load readings as obtained from the spring balance must be multiplied by four, owing to the ratio of the lever arms. Check tests are run on each soil and from the average of these the bearing value curve is plotted. For comparative purposes, the bearing value of the soil is taken as the load in pounds per square inch required to produce a penetration of 0.1.

Adsorption Test.—This test in its present form has been developed by E. C. Lord, of the Bureau of Public Roads, to determine the adsorption of basic analine dye by soils. It probably is an indication of the binding property and bearing value of subgrade materials, and is carried out on air-dried material passing the 10-mesh sieve and on the silt, clay and suspension clay obtained as previously described from the 25-gr. sample of soil.

The dye solution employed in this test consists of one part per thousand crystal violet in distilled water and a sufficient quantity should be made up in advance to assure a constant strength for a large number of tests.

The test is carried out as follows: A sample of the soil weighing 0.20 gr. is transferred by means of a wide-necked funnel to a cylindrical separatory tube of about 5-cc. capacity containing about 1 cc. of the solution and is then thoroughly stirred with a platinum or polished brass rod until the solution is completely decolorized and the coagulated clay sinks to the bottom of the tube. It is then run into a filtering tube inserted in an upright position in a 25-cc. graduate. This filter tube should measure about 6 by ½ in. inside diameter and be drawn at the lower end for a distance of 1 in. to a straight stem having a ⅛ in. inside diameter. The tube is closed by a small disk of filter paper firmly held in place by a ground glass stopper tube which encloses the end of the stem for a distance of ¼ in. It should be filled with water to assure an even flow of liquid through the soil to be tested and the filter paper should be pressed in place when wet.

The filter tube containing the flocculated soil and decolorized liquid is allowed to drain off into the graduate, when additional dye is added and the filtration continued until a marked coloration appears in the liquid passing through the filter paper, indicating the end point of the reaction. The volume of decolorized solution is then read off in cubic centimeters.

The tests for silt, clay and suspension clay as obtained by the mechanical analysis of the sample, are carried out in the same manner excepting when the quantity of material obtained is very small, requiring a more dilute dye solution (1 : 5000), or when the original soil consists mainly of silt and sand. In the latter case, the weighed sample is washed directly into the filtration tube and the water allowed to drain off before adding the dye.

The results of the tests are recorded in cubic centimeters of dye at a concentration of 1 : 1000 adsorbed for unit values (1 gr.) of the silt, clay, suspension clay, and soil as a whole.

Slaking Value.—This test in its present form can only be considered as tentative as it is felt that it can be considerably improved upon. It will be given, in order that we may benefit by any suggestions which might be offered.

A quantity of soil approximately 400 gr. in weight is mixed with water until it has a consistency comparable with the "normal consistency" of Portland cement. It is then pressed firmly into the mold by hand until filled, the surface being troweled off smooth. After remaining in the mold for about three hours, the briquettes are removed and are allowed to air dry for approximately eighteen hours, after which time they are placed in an oven (temperature not to exceed 100 deg. C) and dried for five hours. At the expiration of this time, the briquettes are placed in a dessicator until cool and then tested. The slaking value is the time in minutes required for the briquette to fall through the brass ring. The slaking value given in the table is the average of the three most consistent values obtained from the four briquettes tested.

Definition of Terms.—Owing to the many different interpretations placed upon such terms as sand, silt, clay, and suspension clay it is deemed advisable, in order to avoid confusion, to define these terms according to the sense in which they are used at the U. S. Bureau of Public Roads.

Sand.—That portion of the soil sample which passes a 10-mesh sieve and which is retained on a 200-mesh sieve and which settles out of a 500 cc. mixture of soil and water after eight minutes' sedimentation as described under "Mechanical Analysis."

Silt.—That portion of the soil sample which passes a 200-mesh sieve and which settles out of a 500 cc. mixture of soil and water after eight minutes' sedimentation as described under "Mechanical Analysis."

Clay.—That portion of the soil sample which remains in suspension after eight minutes' sedimentation but which is thrown down when a centrifugal force equal to 500 times the force of gravity is exerted upon the suspended material for a period of one-half hour. The suspended material is obtained as described under "Mechanical Analysis."

Suspension Clay.—That portion of the soil sample which remains in suspension when a centrifugal force equal to approximately 500 times the force of gravity is exerted upon the suspended material for a period of one-half hour. The suspended material is obtained as described under "Mechanical Analysis."

Mechanical Ratio.—The mechanical ratio of a soil is the quotient obtained by dividing the sum of the percentage of sand and the percentage of silt by the sum of the percentage of clay and the percentage of suspension clay, the percentages used being those obtained from the Mechanical analysis. This ratio expresses the relation between the inert material (sand and silt) and the active material (clay and suspension clay).

Percentage of Voids.—The percentage of voids of a soil can be obtained by dividing the difference between the apparent volume and the true volume of soil by the apparent volume, and multiplying the result by 100. The data necessary to compute the apparent and true volume of soil are obtained from the volumetric test of the soil under water-capacity conditions.

Moisture Index.—The moisture index factor is the ratio between the volume of moisture in the soil and the volume of voids in the soil when it has dried from its water-capacity condition. The moisture index may be found by dividing the volume of moisture by the apparent volume of soil less the soil content. The moisture equivalent index and the capillary moisture index are obtained by substituting the moisture-equivalent moisture and the capillary moisture, respectively. Both of the above indices are calculated on the basis of 100 gr. of soil, that is, the numerator is the weight of moisture in 100 gr. of soil and the denominator is the volume of voids in 100 gr. of soil.

Tests show that as the mechanical ratio decreases, the moisture equivalent increases. This means as the clay content of a soil increases, the percentage of moisture which can be retained in the soil by a force equal to 1000 times the force of gravity increases. This relation should prove useful in studying the problem of subgrade drainage as it is reasonable to suppose that soils having low moisture equivalents can be more easily drained than those having high moisture equivalents.

Tests also show that as the mechanical ratio decreases the percentage volume change increases. It has also been shown that a relation exists between the percentage volume change of a soil and its adsorption number and between the percentage volume change and the capillary moisture index.

In considering the volume change of a soil, we find from the above relations that it is dependent upon the quantity and character of the clay content of the soil as well as upon the moisture content of the soil.

Soils which are rich in clay, that is, those having mechanical ratios less than unity, have high bearing values, provided the adsorption of the soil is high, and also in general have high capillary moisture indices. This would indicate that those soils which are rich in clay and also highly adsorptive have the ability to take up considerably more water than those which are rich in clay and not highly adsorptive and still maintain good bearing value. It is also interesting to note that a combination of high clay content, high adsorption and high bearing value is accompanied by high volume change. It would seem that soils of this nature could be greatly improved upon by the addition of some material, such as sand, which would tend to reduce the volume change of the soil. It seems reasonable to suppose that when the cubic centimeters of moisture in the soil are less than the cubic centimeters of voids which exist in the dry soil, the soil should give good bearing value. This condition is fulfilled when the moisture index of the soil is less than unity. Tests show that with only one exception, the bearing value is high when the moisture index is less than unity. On the other hand, it is possible to obtain high bearing values when the moisture index is as high as 2.0 but it should be noted that in these cases the adsorption is generally high. It is evident that with the exception of those soils which are highly adsorptive, as the moisture index of the soil increases above unity, the bearing value or stability of the soil decreases and it is believed by the author that every soil has a fairly definite critical moisture index, that is, an index above which the bearing value is good, and below which it is poor. During the coming year it is proposed to obtain data which will establish this index as well as the laws which govern it.

Conclusions—There seems to be at least three important factors upon which the physical properties of subgrade soils are dependent, namely, the gradation which is expressed by the mechanical ratio, the moisture content which is expressed by the moisture index, and the character of the soil which is expressed by the adsorption number.

These facts influence the physical properties of subgrade soils in the following manner.

When the clay content of the soil is increased, its ability to take up and retain moisture is increased and its percentage volume change is increased.

The character of a soil influences its percentage volume change as is evidenced by the fact that for increasing adsorption numbers, the percentage volume change increases.

When the moisture index of the soil is less than unity, the bearing value will be high.

When the moisture index of the soil is above unity, high bearing values can be obtained, provided the adsorption of the soil is high.

In conclusion, the author wishes to emphasize the fact that the above statements are based on laboratory tests alone and can only be considered as being comparative, no attempt having been made to correlate this data with field conditions, although this phase is to be considered during the next year.

Types of Federal Aid Roads

Various types of Federal aid roads are built in different sections of the country. According to the Bureau of Public Roads of the United States Department of Agriculture, this variation is due largely to availability of materials, volume of traffic, and climatic conditions. The 18,299 miles of Federal aid road completed on July 31 have been distributed among the eight major types of construction as follows: Graded and drained, 2,528 miles; sand-clay, 2,222 miles; gravel, 7,013 miles; water-bound macadam, 456 miles; bituminous macadam, 654 miles; bituminous concrete, 699 miles; concrete, 3,350 miles; and brick, 287 miles.

Cost of Operating Ford Cars

The Engineering Department of Los Angeles, Calif., owns and operates 20 Ford automobiles. The average operating cost for the year ending June 30, 1922, was 5.76 ct. per mile run for 2-passenger roadsters and 5.83 ct. for 5-passenger touring cars. These figures include fuel and oil, depreciation, tires and repairs, miscellaneous expenses, and interest and insurance.

Present Tests for Granite Block

Their Value in Determining the Probable Wear in Pavements, Discussed in Paper Presented at 28th Annual Convention of the American Society for Municipal Improvements.

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In studying the present tests for granite in determining its suitability for paving blocks it may be well to study the history and development of these tests.

At first no tests were made but the blocks were cut, paved and simply submitted to the service test. Architects had required the test for crushing strength of granite which was to be used in building construction. Some of the engineers thought that a test should be called for and knowing of the architects' test, they inserted this in the specifications. Various minimum requirements were used varying from 15,000 lb. per square inch up to even 30,000 lb. per square inch. When the minimum requirement was much over 15,000 lb. it was found that many granites which had proved very satisfactory under the service test for long periods were barred out. A study showed that no very definite relation could be found between this test and the behavior of the granites under the actual traffic conditions. In 1915 the American Society for Municipal Improvement adopted specifications with tests for impact or toughness and the abrasion test for French coefficient of wear including minimum requirements for moderately heavy traffic and heavy traffic.

At that time these tests seemed about as fair as any which had been tried, although they were not devised for this purpose. Since then from observation of results obtained in laboratories and results in the pavements its has been difficult to find much relation between these tests and the actual service test in the streets.

These two tests were designed to measure the relative resistance to impact and wear of broken stone for use in macadam road pavements, and they do not fit in with the conditions surrounding the use as paving blocks, to any great degree.

The object of this paper is not to advocate the abandoning of all tests, but to encourage experimental study for the developing of more practical tests by calling attention to the defects of those now used in the testing of granite for paving blocks.

Defects of Toughness and Abrasion Tests.—In the toughness test the sample is very small, 1 in. diameter and 1 in. high, and great care is necessary in making the sample or there will be wide variation in results. A little carelessness in making the test specimens from the same sample may result in an error equivalent to 25 per cent of the total range of all granites used in the eastern portion of the United States. This chance for error detracts greatly from the value of the toughness test aside from the fact that it is a test that does not approximate the wear conditions in the street.

In the test for French coefficient of wear also the error may be as great as 25 per cent of the total range of the granites, due to the method usually used in breaking the test pieces with a hammer which may start incipent fractures and also because of the irregularity of the shapes of the pieces for the test.

The Bureau of Public Roads has developed a machine for breaking out the test pieces by pressure which obviates the fault of incipent fractures and produces more regular shapes, but this cuts down the range of results on the various granites and makes it more difficult to differentiate the various granites.

This test does, however, show whether there is any real disintegration or not. The old idea that discoloration indicated disintegration has been thoroughly exploded. Discolored or "sap" stone may in many cases show a greater strength than the clear stock from the same quarry. Real disintegration will show up in this test and herein lies its chief value in giving the relative strength of the material from the same quarry, although it is not of much value beyond this in indicating how it will wear when paved in the street.

Modifications in Preparing Test Specimens.—With the object of improving the present test for French coefficient of wear for granite block pavements the laboratory of the Bureau of Public Roads has made modifications in the methods of preparing the test pieces for the Deval abrasion test as previously stated. The samples being broken into small cubical blocks by means of a machine instead of by hand. The machine consists of a 20-ton forcing press such as is used in automobile repair shops for forcing the gears from shafts. This press is equipped with both stationary and movable knife edges and it has sufficient power to break a standard 5-in. granite block. This machine breaks the block into small cubes rapidly and much more accurately than can be done by hand and in addition avoids the danger of starting incipient cracks in the stone. In other words, the test pieces have good, clean, fairly regular faces and are approximate cubes.

Abrasion tests upon these fragments showed a greater co-efficient of wear than the old method, but the results checked much better, although the range in values obtained with the different granites was much more limited than with the hand-broken specimens. In order to increase this range, Mr. Jackson tried a modification of the abrasion test which was proposed by Messrs. Scofield, Mattimore and others, as follows: A number of longitudinal slots 1/16 in. each in width were milled in the abrasion cylinder, and the test was run on granite from 12 representative quarries, making two to three tests on each kind of granite. Tests were also run on these same granites using the present method, and the results were compared. The elimination of the dust cushion gave lower coefficients of wear but the maximum variation of check tests was much less. In general the coefficients of wear were somewhat over 2 points lower than with the present standard apparatus.

The total number of tests made was not sufficient to draw definite conclusions as to what minimum coefficient should be specified, but the maximum variation in check tests was sufficiently low to indicate that this was a step in the right direction. It is urged that more tests be made along this line and if they prove as consistent as those already made by the Bureau of Public Roads and several other laboratories, it may be possible to select definite minimum requirements to be used with these modifications in this test which will be an improvement on the present standard so that this test may be much more satisfactory than at present. This test is valuable as a means of proving whether a granite is disintegrated to any extent or not.

Bureau of Public Roads' Service Test.—Several years ago the Bureau of Public Roads constructed 19 sample sections of granite block pavement from different quarries using different forms of filter and cushion and tested them by an accelerated traffic test which consisted of a machine having a frame carried upon rails which were parallel and on either side of the sample sections of pavement. These rails were supported firmly by concrete stringers or beams which also formed the sides of the pavement sections being tested. The subgrade was natural earth on a side hill having a gentle slope. Upon the subgrade 18 in. of rammed cinders were placed and then 8 in. of Portland cement concrete was deposited. On this foundation was constructed the various cushions and the test sections of granite pavement. In the frame of the testing machine were cast iron discs having a diameter of 4 ft. which ran freely in the frame. This frame was drawn back and forth over the test sections by means of a cable. This is the nearest approach to a service test which has yet been devised. However, it was not possible to draw very definite conclusions from the results obtained as there was more or less settlement of the concrete foundation, probably due to the large amount of cinders underneath it, and the narrowness of the pavement between the concrete foundations of the rails. It would seem as though some such form of practical test could be devised which would not be so cumbersome or expensive but that the laboratories could afford to use it.

An important point to be borne in mind in devising a better test is not so much how individual blocks will act under the test as how they will act when combined as in a pavement with the usual joint spacing and the different fillers in the joints.

A simple form of accelerated traffic test would be the ideal one and approximations of this are what should be aimed at in securing a more practical test.

In summing up the value of the laboratory tests now used to determine the wear of granite in granite block pavements the conclusion is reached that the test for French coefficient of wear is the only one of value and the principal advantage of this is to determine if disintegration has progressed sufficiently to render the stone unsuitable for use in pavements, provided the coefficient of the normal clear stock of that quarry is known. The value of this test will probably be increased by using the modifications as were tried by the U. S. Bureau of Public Roads.

In the test for abrasion it would be advantageous to use the percentage of wear directly rather than the French coefficient as in the lower percentages of wear the equivalent French coefficients change greatly for small percentage changes.

How the Pittsburgh Traffic Count Was Made

Method of Counting Vehicular Traffic and Recording Results Described in Paper Presented Before Engineers' Society of Western Pennsylvania

By WINTERS HAYDOCK,
Chief Engineer, Citizens' Committee on City Plan of Pittsburgh.

If we are to square ourselves to the job of anticipating in our large cities a condition of traffic congestion (the seriousness of which may not be calculated) by forehandedly applying such remedies as may be within our power, we must begin by a careful scrutiny of existing conditions. This implies, first, a study of the existing plan of streets to determine upon a scheme for the arterial system of major thoroughfares as distinguished from the secondary or local streets of the general system. It is most important that in developing a city plan this distinction be as clearly drawn as circumstances will permit. Only by the development of a clearly defined system of continuous arterial thoroughfares of adequate capacity can proper circulation for the whole locality be assured.

One of the primary objects of the Citizens' Committee was the producing of a plan for such a system of main thoroughfares. The traffic count was made as an incidental aid to the working out of this major street plan.

The traffic count was undertaken with a full appreciation of the fact that there are certain limitations to its value as a guide to the development of a street plan. Artificial or non-permanent conditions may materially affect the use of certain streets. The condition of the paving, for example, may have an important influence on the traffic using a given route; or the making of new connections and the opening of new streets may completely dislocate the existing traffic equilibrium. At best, a traffic count can be considered only as a useful aid.

In the fall of 1920 the Citizens' Committee on City Plan decided to make a vehicular traffic count as a help to the study of the major street plan which it was then undertaking. An investigation showed that to make a complete and thorough count covering all portions of the city, with a sufficient number of counting points to determine in detail the movement of traffic along, into, and from all of the principal streets, would involve an expense for which it did not appear that sufficient funds could be made available. The committee would have preferred to make a comprehensive count of this character, covering in detail the entire city, but it was necessary that the expenses be confined within practicable limits. The co-operation of the City Planning Commission was sought and secured, and its Chief Engineer, Mr. U. N. Arthur, assigned the work of assisting the Citizens' Committee in the count and tabulation to the staff of the Transit Commission, which was at that time functioning under the direction of the City Planning Commission. Mr. A. B. Carr was assigned to take active charge of the work.

As this was to be of considerable interest to the city, and particularly to the City Planning Commission, as well as to the Citizens' Committee, it was agreed that there should be a division of expenses, the arrangement being that such city employes as were available would be used for the count and the clerical work, while the remainder of the force necessary would be employed and paid by the Citizens' Committee.

The Scope of the Count.—In view of impossibility of making a city-wide count with the means available, it was decided that the scope of the count should be confined to a study of traffic affecting the central business area or the areas adjacent thereto, together with traffic at a few special exterior points of particular interest in developing the major street plan. In so far as the investigations applied to the triangle district (the central business district, between the Allegheny and the Monongahela west of Grant St.) the objects of the count were two-fold: first, a study of traffic passing through the various entrances of the triangle as to both quantity and type, and of the principal routes of dispersion of that traffic beyond these entrances; and second, a study of the traffic passing into the triangle to determine the percentage and routes of that portion which passed through merely as a part of a trip between two districts outside of the triangle. It was believed that the percentage of this latter class of traffic would be found to be large and that, if it could be removed from the triangle by the development of a system of by-pass thoroughfares, there would result an appreciable measure of relief for the congestion of the triangle district.

It was decided to make no counts inside of the encircling ring of entrances to the triangle. Such counts might be of value in studying certain phases of the traffic problem within the triangle, but would not be necessary to the objects of the count as decided upon.

How Vehicles Were Identified.—In order to determine the number of vehicles passing through the triangle on through trips it was necessary to devise a means of identifying each individual vehicle as it passed the various counting points. Several plans for this were discussed. The only feasible one appeared to be the recording of the license number of every vehicle passing each of the counting points, together with the time and direction of its passing. It was realized that this would be a very difficult thing to do at points of heavy traffic flow; but experiments were made which indicated that a proper number of checkers could obtain results having a very high percentage of accuracy. So far as the writer knows, a count of this character has never before been attempted.

Fifty-one counting points were chosen, each point being designated by a number. The first 16 of these are the entrances to the triangle. The remainder are located on the principal thoroughfares at various distances from the triangle, and form something like a belt around it. There were 17 of these external counting points in the central and East End district, 7 on the North Side, and 11 on the South Side.

Students Help in Country.—A schedule was made out showing the number of men which it was believed would be required to do the checking at each counting point, this number being based upon the estimated weight of traffic at each point. This schedule also provided for a number of traveling relief men who were to go from point to point as needed. It also divided the counting points into five districts, each to be under the care of a supervisor or foreman.

Arrangements were made with the Dean of the School of Engineering of the University of Pittsburgh for the employment of students of that school to help in the counting. It was arranged that those so employed were to be released from attendance upon classes upon the day of the count. The co-operation of the faculty and students of the School of Engineering contributed very largely to the success of the count. Students were employed to the number of 136, and city employes to the number of 75. The students were paid at the rate of 60 cents an hour, which was the standard rate for student work at the University during the period of high wages then prevailing.

The count was made on Oct. 28, 1920, between the hours of 7 a. m. and 6:15 p. m. Had the count been undertaken earlier in the season the time of ending would have been chosen as 7 p. m., but at that season of the year it became too dark to read numbers accurately shortly after 6 p. m.

Instructions for Checkers.—On the day before the count an instruction sheet was given to each checker indicating in full his location and duties, together with the symbols and methods to be used in recording. He was also given a blank record book.

All license numbers were recorded, one squad recording traffic in one direction only. The record was subdivided into 15 minute periods by turning a new page in the book at the end of each period and marking the time at the top of the next page. Motor trucks and commercial vehicles were designated by the symbol T and horse-drawn vehicles by H, while army and mail trucks were designated by A and M, respectively. As no license number could be recorded for horse-drawn vehicles or for army and mail trucks a numerical record only was obtained of these.

Method of Tabulating the Count.—The work of tabulating the count proved to be more laborious than that of making it. A tabulation was first made showing the number of vehicles of each class passing each counting point by 15-minute periods, a separate sheet being used for each counting point. As the object of the count required that the record of appearances of each vehicle at the various counting points be so consolidated as to make its movement traceable, it was necessary to devise a means to assemble the scattered notations for each individual vehicle. To accomplish this expeditiously required considerable study, as the total number of appearances of vehicles recorded was 131,021.

The following method was employed: The record of each appearance of a vehicle was copied upon a separate card, the cards being slips of paper two by four inches in size. The record on each card included license number, type of vehicle, time period, direction of travel, and identity of counting point by number. These cards were then sorted by hand into numerical order according to license number, and this automatically brought the cards for any one license number together. This sorting was a very laborious process, but was expedited by several ingenious methods.

The record from the cards was then copied on printed forms 17x26 in. in size—one horizontal line being given to each license number. These sheets were ruled vertically for the time of day, each 15-minute period having a separate column. In transferring the record of any one appearance of a given license number from the card it was necessary only to record the counting-point number and the direction symbol in the proper time column. When these sheets were completed, a glance along any horizontal line gave a complete history of the movements of the day for that particular vehicle in so far as it passed any of the counting points.

The above described work of tabulation was carried out under the direction of Mr. Carr of the Transit Commission with the assistance of a few city employes and a large number of high-school students who were employed by the Citizens' Committee through arrangement with the Board of Education.

With the record sheets above described before us, we were able to trace the movements of vehicles entering the triangle at any point in order to determine what portion of them were probably making through trips which would not have necessitated their entering the triangle at all had there been an adequate system of by-pass thoroughfares provided. It was assumed that vehicles in this class entered and passed out of the triangle within the same or consecutive 15-minute periods at such points of entrance and exit as would indicate that a through or continuous journey was being made rather than a return or loop journey. It was found that over 18 per cent of all traffic entering the triangle was of this class. It is probable that this percentage could be materially increased on account of vehicles delayed beyond the limits of two consecutive 15-minute periods while passing through, and on account of vehicles passing through the triangle and making stops for reasons which would not necessitate a trip to the triangle.

Road Grading With Elevating Grader With 30-ft. Carrier

A large elevating grader with a 30 ft. carrier is being used by N. L. Terr on a 12 mile road contract in North Carolina, according to The Earth Mover, from which this note is taken, the contract involves the handling of 400,000 cu. yd. of material throughout the 12 miles. Chief interest attaches to fill across the river bottoms, which the contractor correctly diagnosed as machine work. The soil is sandy loam and the fill crosses meadow and cultivated land in equal parts. A mile and a half of the fill is from 9 to 17 ft. high and a second mile and a half runs from 2 to 10 feet in height. The three miles of fill requires the placing of 200,000 cu. yd. of material.

Adjoining one end of the fill is a cut through a hill, with a maximum depth of 22 ft. This is being taken out with an elevating grader and dump wagons and the material used in making 2,000 feet of the fill, which averages 10 feet in height. There are 4,200 ft. of side borrow work, comprising the heaviest part of the fill, which in places is 81 ft. wide at the base, and the borrow-pit, 60 ft. wide. Six-foot berms are required, sloping back on a 1 to 4 grade to the edge of the borrow pit.

The method is to cast this fill with the elevating grader to a depth of 7 ft. and then top off with wheelers and dump wagons in the usual way. Some of the material has to be handled twice but as the machine casts as high as 2,000 cu. yd. in 10 hours, earth can be handled twice with economy. In the absence of teams and wagons to pack the fill, the contractor's first idea was to use a roller. He found, however, that the sandy soil would pack sufficiently under a road machine. Instead of rolling, therefore, he levels each successive layer with a blade machine. This economical method of handling the situation is meeting the full requirements of the State Highway Department.

The work started May 1st, and notwithstanding a great deal of wet weather the machine handled 24,200 cu. yd. during the first month of 19 working days; as 6,500 cu. yd. of this was handled twice, the machine really handled 30,700 yd. The elevating grader is fitted with a disk plow and a 30-ft. carrier, carries a counterweight of 1,500 lb., and is hauled very successfully by a Best 60-Hp. tractor. During the long days of June the superintendent established a double shift and worked the big machine from early dawn until dark. The first shift goes out about half past two in the morning. By the time they have "oiled up" and are ready to work they are able to see the fill. The second shift goes on about midday and works until 8:30 at night. A large daily yardage is the result.

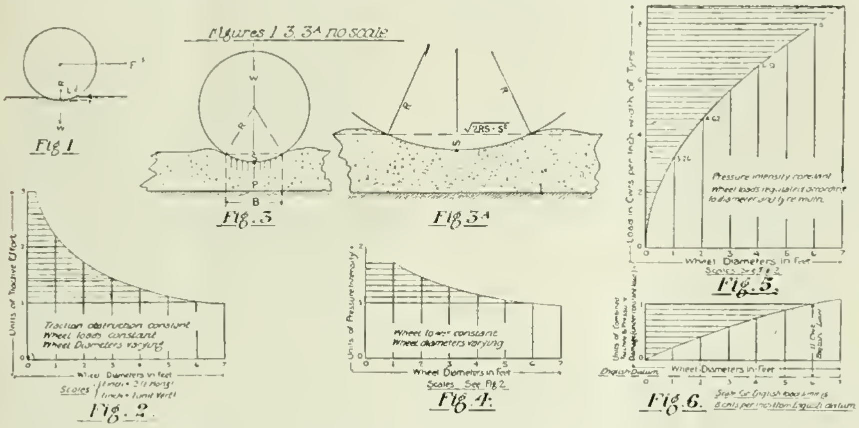
In addition to the machine outfit mentioned, the contractor is using No. 5 Western plows with 3-up teams and No. 2 Western wheeled scrapers, small wheelers being required because of the hard climb out of the borrow pit. There are 25 teams of mules on the job. Negro labor, of course, is used, the men boarding themselves and getting supplies from the camp commissary.

Effect of Wheel Diameter on Highways*

Analysis of Varying Tractive Efforts Required to Move Wheels of Varying Diameter and Comparison of Pressure Exerted on Road Surface

By J. R. KEMP and D. A. CRAWFORD

The authors have recently investigated the problem of the relative damage caused to roads by wheels of varying diameter in connection with the preparation of regulations governing the weights of loads on vehicles under the Queensland Main Roads Act of 1920. The following analysis indicates the varying tractive efforts required to move wheels of varying diameter. Each wheel is considered as having tires of unit width and to be under unit load.



Figs. 1-6.—Diagrams Illustrating Damage Caused to Roads by Wheels of Varying Diameter.

Tractive Effort for Wheels of Varying Diameter.—The tractive effort is a measure of one class of damage to roads, that is, shear:—

Referring to Fig. 1, let W represent the wheel load, S the constant height of a road obstruction, R the wheel radius, F the tractive force, L the perpendicular distance between the obstruction and the radius of the wheel which touches the road surface.

Assume S constant and W as a unit load.

$$L = \sqrt{R^2 - (R - S)^2}$$

and since S is very small in comparison with the radius

$$L \doteq \sqrt{2}\ \sqrt{RS} \text{ very nearly}$$

Taking moments.

$$F(R - S) = \sqrt{2}\ \sqrt{RS} \times W$$

therefore where C is a constant we may write

$$F = \frac{C\sqrt{R}}{R - S}$$

or F is nearly proportional to $R^{1/2}$ when W is constant.

The slight upward pull on a low wheel would slightly decrease the value of F.

Figure 2 is a graph indicating the relative shear damage caused by the tractive force required to move a constant load on wheels of varying diameter.

Wheel Pressure on Road Surface.—A comparison of the pressures exerted upon an elastic road surface by rigid wheels of varying diameter and unit tire width and under unit load will now be made. It will be assumed that the road is of fixed crust thickness upon a nearly rigid foundation. It is obvious that wheels of varying diameter under the above conditions will dimple or deflect the surface of the road to different degrees. For the purpose of simplicity the width of road acted upon will be taken as the tire width.

Hooke's law enables us to state that the pressure at any point will be proportional to the deflection at that point.

Referring to Fig. 3, let B be a chord of the contact arc (and nearly equal to the arc), W the total wheel load, S the greatest surface deflection, M a constant depending upon the distribution of pressure (probable value 1.5), R the wheel radius, P the maximum intensity of pressure.

$$\text{(1)}\quad \text{Then } P = \frac{MW}{B} \text{ or } B = \frac{MW}{P}.$$

$$\text{(2)}\qquad P = \frac{MW}{B} = CS$$

where C is a constant depending upon Young's modulus of the material of the road crust and the thickness of the crust.

$$\text{(3)}\quad \text{Hence } B = \frac{MW}{CS}.$$

$$\text{(4)}\quad B = 2\sqrt{2RS - S^2}$$

and since S is very small in comparison with R, we may write

$$\text{(5)}\quad B = 2\sqrt{2}\ \sqrt{RS}$$

and from (3) and (5)

$$\frac{MW}{CS} = 2\sqrt{2}\ \sqrt{RS}$$

$$\text{therefore}\quad \frac{W}{\sqrt{R}} = 2C\sqrt{\frac{2S^{3/2}}{M}} = KS^{3/2}$$

and $\frac{1}{\sqrt{R}}$ is proportional to $S^{3/2}$ for constand loads.

The maximum pressure exerted upon the road surface is one measure of the destructive effect of the wheel.

Fig. 4 is a graph illustrating the relative destructive effects, due to pressure, of wheels of varying diameter having a unit tire width and under unit load, in accordance with the statement that $\frac{1}{\sqrt{R}}$ is proportional to $S^{3/2}$.

Another statement of the case is given hereunder, the results being identical in each case.

The result, although possibly giving a measure of the relative damage under uniform loads, is not really indicative of the manner in which loads should be limited according to wheel diameter.

Both Figs. 2 and 4 indicate that there is very little advantage to be gained by increasing the diameter of any wheel beyond 6 ft.

Summarizing the above result, the damage done to the road is made up of two factors—K_1 due to the road pressure, and K_2 due to the shear. It is shown that K_1 varies as $\sqrt{R}$ and K_2 is a constant if the load varies as $\sqrt{R}$. Hence, by adopting $\sqrt{R}$ as the factor determining the load variation per inch width of tire, the total damage $K_1 + K_2$ is constant.

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*From The Commonwealth Engineer, Brisbane, Australia.

Road Drag Competition in Saskatchewan

In 1918 the Department of Highways of the Province of Saskatchewan, Canada, inaugurated a road drag competition for the purpose of inducing as many of the rural municipalities as possible to make a serious attempt to give the drag a thorough try out. There are 300 rural municipalities in Saskatchewan, and the competition was open to each of these to make one entry of a stretch of road not less than two nor more than six miles long. This competition has been carried on every year since by the Department. The number of entries increased from 49 in 1913 to 171 in 1921 and the miles dragged from 124 to 670. The average cost per mile increased steadily from $11.86 in 1913 to $19.92 in 1921. The average cost of dragging per mile per season was obtained from the returns which are made by each entrant as required by the rules.

In 1914 requests were sent out to all the 300 rural municipalities in the province to make returns to the Department of the number of drags in use in each rural municipality, the number of miles dragged that year, and the total cost. Similar information was obtained for the years 1919, 1920 and 1921. The returns showed that there was an average of only 3 drags in each of the 300 rural municipalities in 1914 dragging 7.7 miles, and that these figures were increased to 10.4 drags for covering 43.3 miles in each municipality in 1921.

Bidding Prices on Federal Aid Road

Accepted bid prices on Federal aid roads averaged for the whole United States for the month of July are as follows: Common excavation, 35 cts. per cubic yard; unclassified excavation, 63 cts. per cubic yard; and rock excavation, $1.29 per cubic yard. The following prices per cubic yard are for surfacing material in place on the road: Gravel, $1.65; sand clay, $1.43; and crushed stone, $2.72. Surfacing per square yard in place on the road cost as follows: Gravel, 50 cts.; bituminous macadam, $1.64; bituminous concrete, $2.40; plain cement concrete, $2.09; brick, $3.40. Reinforcing bars, 4½ cts. per pound, and structural steel, 8 cts. per pound, both in place.

Methods of Constructing Brick Pavements

Present Status of Paving Brick and Brick Pavements Analyzed in Paper Presented at 8th Annual Conference on Highway Engineering at the University of Michigan

By ARTHUR H. BLANCHARD,
Professor of Highway Engineering and
Highway Transport, University
of Michigan.

During the past decade the brick pavement has had an unusual history of development. Paving brick have been manufactured in a great variety of sizes and types. Changes in methods of construction have been many and varied, some of which have been very unsatisfactory. Notwithstanding these conditions, the properly constructed brick pavement has remained a generally accepted type for use on state and county trunk highways, subjected to intensive and heavy traffic, and for use on many classes of streets in municipalities.

The time is opportune to analyze the present status of paving brick and brick pavements, especially from the standpoint of types of paving brick and also because that leader of practice for many communities, the National Paving Brick Manufacturers' Association, recently has given material aid in the simplification of the paving brick situation and is now advocating the general utilization of an efficient method of construction.

In this discussion of brick pavements, only two important characteristics of an ideal pavement will be considered. It is generally acknowledged that satisfactory pavements must be durable and waterproof. A brief analysis of the several types of brick pavements will be considered from the standpoint of these two essential characteristics.

The Earlier Brick Pavements.—In the early days of brick pavement construction, a sand foundation and sand filler were employed. This foundation proved inadequate for even medium traffic while the joints, being filled with sand, allowed water to pass through them to the sand bed below. A movement of the sand in the joints and bed naturally followed with the resulting displacement of the brick under traffic.

The first noteworthy development was the utilization of the cement concrete foundation, sand cushion and bituminous cement with which to fill the joints. These improvements indicated the application of sound engineering principles to the design of brick pavements. It was soon recognized that one essential feature of this method of construction was to utilize a bituminous cement which would adhere to the brick and would not be susceptible to changes in temperature to such an extent as to make it unsuitable for use as a filler. Unfortunately, some of the bituminous cement fillers employed had a tendency to chip or become brittle in cold weather and flow in warm weather. The results were unfortunate as the joints did not remain filled with bituminous cement and the exposed edges of the brick were chipped or broken off by the impact of iron-tired wheels or horses' hoofs. Fortunately, however, many brick pavements were laid with joints filled with asphalt cement having the proper physical and chemical properties, including a minimum susceptibility to changes in temperature.

In 1911 and 1912, the writer had the opportunity to inspect many sections of brick pavement, with asphalt filled joints, in municipalities in Indiana, Michigan, and Wisconsin. These pavements had joints filled practically flush with the surface of the pavement although they had been subjected to traffic for from 5 to 10 years. The pavements possessed the desirable durability, while the surfaces were waterproof. This type of construction has continued to be used by engineers who are familiar with the best methods of constructing pavements.

Cement Grout Filled Pavements.—The next development was fathered by the National Paving Brick Manufacturers' Association. It consisted in the substitution of cement grout filler for the bituminous cement filler. After several years' use of this method of construction, it was finally conceded that it was very difficult to secure uniformly filled joints by using cement grout and that a monolithic brick slab cracked, due to temperature stresses, thus enabling water from the surface of the pavement to reach the sand cushion, which gradually became displaced. It also became evident that the action of traffic on the weak sections of the pavement surface and on portions of the brick wearing course over the areas of displaced sand cushion caused many failures of brick pavements. These failures were due primarily to contraction stresses. Failure, however, occurred due to expansion stresses, such as the "blowing up" of sections of brick pavements.

Monolithic and Semi-Monolithic Types.—The next developments were also introduced by the National Paving Brick Manufacturers' Association, one of the new methods consisting in laying the brick on a cement mortar bed resting on a cement concrete foundation and the other, laying the brick on green concrete. The joints in both methods were filled with cement grout. These methods are not at present promoted by the association.

West of the Mississippi, the Western Paving Brick Manufacturers' Association has exerted considerable influence. The association advocates the use of what is called vertical fibre brick with the rough surfaces uppermost and recommends that the surface be covered with a squeegeed coat of asphalt and the joints filled with asphalt cement.

At the last meeting of the National Paving Brick Manufacturers' Association, held on Dec. 7, 1921, the association expressed "its confidence in asphalt filled brick wearing surface for street and highway paving properly designed and built with acceptable materials and thorough methods," and the association further declared "its preference for the asphalt filled types of wearing surface" with the proviso that "perferment of the foregoing type of brick wearing surface for general use shall be without prejudice to any other type which may possess peculiar adaptation to special local conditions." In view of the fact that the association has exerted a powerful influence over the practice of the construction of brick pavements in many sections of the country, it is hoped that, as a result of its latest recommendation, the durability of future construction in all sections of the country will not be jeopardized by the use of cement grout as a filler but that bituminous cements, possessing the desired characteristics, will be universally employed.

Requirements for Asphalt Cement Filler.—In order to insure the use of a bituminous cement possessing the desirable practical minimum susceptibility to changes in temperature, the writer, in his private practice in northern states, has recommended, among other requirements, the following clauses covering the penetration of asphalt cement fillers:

Penetration at 25° C. (77° F.), 100 grams, 5 seconds, 30 to 40.

Penetration at 4° C. (39° F.), 200 grams, 1 minute, not less than 15.

Penetration at 46° C. (115° F.), 50 grams, 5 seconds, not more than 85.

In order that the asphalt cement may be economically used to fill the joints, the writer advocates the use of conical pouring cans. The practice of squeeging asphalt cement over the surface of a new lug brick pavement is uneconomical, as a thin surface of asphalt cement is not an essential part of a properly constructed brick pavement. Whereas it may be practical to secure good adhesion between asphalt cement and the rough surface of the wire cut sides of paving brick, the experience of the writer indicates that asphalt cement applied to the glazed surface of paving brick will usually peel off after being subjected to intensive and heavy traffic.

The present types of paving brick manufactured require careful consideration from the standpoint of efficiency construction of durable and waterproof brick pavements.

Varieties of Paving Brick.—A notable economic development resulted from the action of the Secretary of Commerce of the United States, Hon. Herbert C. Hoover, in calling a conference on the "simplification of variety and standards for vitrified paving brick" in Washington on Nov. 15, 1921. This conference recommended the elimination of 55 out of 66 varieties of paving brick used in the United States. The 11 varieties which were retained include two sizes of plain wire-cut brick, two varieties of repressed lug brick, two varieties of vertical fibre lug brick, three varieties of wire-cut lug brick, and two varieties of hillside lug brick.

Leaving out of consideration hillside lug brick, highway departments east of the Mississippi River are primarily interested in the three types, plain wire-cut brick, repressed lug brick, and wire-cut lug brick. The two types of lug brick have been in successful use for many years and their inherent merits are well established. Many highway departments allow the use of either of these types under their specifications. It is well known that the utilization of lugs on the sides of these two types of brick is for the purpose of uniformly spacing in the laying of the brick in pavements and the providing of joints which can be filled satisfactorily.

In 1919, some of the manufacturers of vitrified paving brick began to manufacture a plain wire-cut brick. As a result of the United States Department of Commerce conference, two sizes of this type of brick will be manufactured, namely, 3 by 4 by 8½ in. and 3½ by 4 by 8½ in. As these brick do not have lugs, it is apparent that two requirements relative to depth may be satisfied with one size of brick. For example, the 3 by 4 by 8½ in. brick may be used by highway departments which wish to lay brick with a 4-in. depth and also by those departments which wish to use a 3-in. depth.

Since the introduction of this type of brick, the writer has endeavored to determine its merits and the economy of its use. It is apparent that the following question would naturally arise: Will it be practicable to space the brick during construction so as to provide uniform and satisfactory joints? It was soon evident that the proper construction of a pavement surface of lugless brick would depend upon the ability of the pavers to satisfactorily and uniformly space the brick. Reports from contractors indicated that considerable difficulty was encountered even leading to the use of artificial means, such as the employment of an angle iron, to secure the desired joints in the brick surface.

Experiment to Determine Filler Depth of Filler Penetration.—Information relative to the results secured was so unsatisfactory that the writer decided to construct an experimental pavement in the laboratories of the Division of Highway Engineering and Highway Transport at the University of Michigan. The writer wishes to acknowledge his indebtedness to Professor John H. Bateman, director, Michigan State Highway Laboratory, laboratory assistants and two engineers of the Ohio Paving Brick Manufacturers' Association for their kind co-operation in the construction of the test pavement.

The experimental pavement was constructed within a wooden frame, 2 ft. 6 in. in width and 8 ft. in length, which rested on a cement concrete floor. A sand bed, 1 in. in thickness, was prepared upon which 3½ by 4 by 8¾ in. plain wire-cut brick, furnished by the Metropolitan Paving Brick Co., were laid by one of the engineers of the Ohio Paving Brick Manufacturers' Association. The section was laid to conform with average practice on contract work. A Texaco asphalt cement filler, having a normal penetration of 38, was heated to 350° F. It was poured by one engineer and squeegeed by another engineer of the Ohio Paving Brick Manufacturers' Association in accordance with the standard specifications recommended by the National Paving Brick Manufacturers' Association.

On several rows of brick, complete measurements covering the widths of all end and side joints were taken before the application of the filler. The measurements, expressed in inches, of the end joints of a part of a typical row follow: 1/16, 1/64, ⅛, ¼, ⅛, 1/16, 1/64, 1/16, 1/64. The joints on one side of this row measured as follows, there being two measurements to each brick due to the fact that the bricks were laid to break joints in adjacent rows: ⅛, ¼, 1/16, 1/16, ¼, 3/16, ⅛, ⅛, 1/16, ⅛, 5/16, 3/16, ¼, 1/32. The measurements on the other side of this row of brick were as follows: ⅛, 1/32, 1/16, ⅛, 1/64, 1/64, 1/64, ⅛, 3/16, 3/16, ¼, 3/16.

With the approval of the engineers representing the Ohio Paving Brick Manufacturers' Association, the pavement was taken apart four days after it was laid. The depth of penetration of the asphalt cement on the sides of the brick was found to vary from 0.1 to 3.5 in., the full depth of brick. The average depths of penetration on three sets of six consecutive bricks were 0.7, 1.2 and 1.6 in.

The results obtained in the construction of the test pavement conform with the results which one might expect from the use of plain brick without some artificial means of securing suitable open joints. Even if some method, such as the use of an angle iron, was employed to secure uniformly spaced plain wire-cut brick, there is no guarantee that the brick would not be displaced during rolling prior to the application of the asphalt filler.

Considering the established fact that successful asphalt filled brick pavements may be constructed with repressed and wire-cut lug brick and that the use of plain wire-cut brick is accompanied with great risk relative to securing well filled joints, the writer is of the opinion that conservative practice dictates that only lug brick should be employed. From the standpoint of the economies of construction, the use of the plain wire-cut brick is not justified. There is no indication at present that there is material difference in the price per thousand of the lugless brick and the lug brick. Furthermore, granted an increase in cost of lug brick over lugless brick, the excess cost of lug brick is a good investment from the standpoint of insuring the construction of a durable pavement with the joints properly filled with asphalt cement.

Suggestions for Design of Street Crowns

New Cross Section Giving Proper Velocity of Run-Off Proposed in Paper Presented at 28th Annual Convention of American Society for Municipal Improvements

By G. A. CRAYTON,

Highway Designer, South Dakota State Highway Commission.

Why crown a street? Drainage. Why shape the crown as we do? Because MacAdam, Telford, the French road builders after the Romans, shaped theirs with a flat slope at the center and a (comparatively) steep slope at the sides. We have all followed the lead of the ancient road builder whose name is lost to us, who first used this shape. There are two principal advantages to this kind of crown; (1) it is pleasing to the eye, and (2) it can be so designed as to give a uniform depth to the run-off.

In some cities it has been found cheaper to remove the street dirt before it has been washed into the sewers. Others are so situated that the storm sewers have sufficient slope to remove such accumulations without deposit in storm sewers. In the first instance, we should design our street so that the velocity of the run-off will never be great enough to carry the dirt to the gutters. In the second instance, the velocity should be great enough to carry at least a reasonable amount of the dirt away. In either case, the object sought should be to obtain the proper velocity to accomplish the results desired. The following is offered as an aid to secure such results.

Securing Uniform Velocity.—It will be seen at once that a uniform velocity should be secured. The most reliable formula relating to velocity of water flowing in a channel is that by Chezy, modified by Bazin. It may be urged that since this formula applies to open channels, it would not apply to a sheet of water flowing over a street paving. But it is believed the possible error would be small.

The formula is

$$V = C\sqrt{rs} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where V is the velocity in feet per second.

C is a constant dependent on the condition of the channel and determined by experiment.

r is the hydraulic radius

s is the slope expressed as a decimal

$$r = \frac{\text{cross sectional area}}{\text{wetted perimeter.}}$$

If we consider a depth of d over a width of 1 ft., $r = \frac{1\,d}{1}$

Therefore r varies directly as d...(2)

If we assume that the intensity of rainfall is constant over the area considered, then with V constant (as we wish to obtain) d will vary directly with the distance from the center line of the paving................(3)

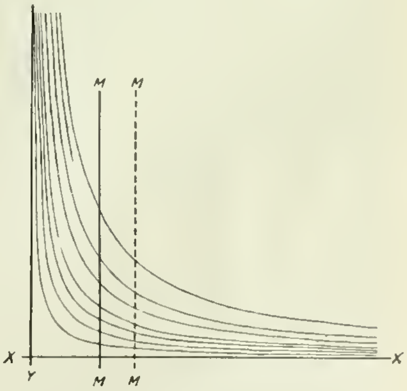


Fig. 1.—Group of Curves Corresponding to the Equation xy = k.

Or, combining equations (2) and (3), r varies directly as the distance from the center line.

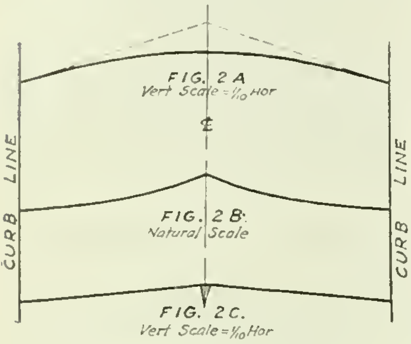
Then, at any point, if it is desired to obtain a constant velocity V, C in the formula being constant, the expression $\sqrt{rs}$ must remain constant, or in other words, the cross section of the pavement should correspond with the equation

$$rs = k' \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

But, since we have seen from equation (3) that r varies directly with the distance from the center of the paving, and since the slope S expressed as a decimal represents the tangent of the angle, or vertical distance, we can replace r and s by x and y, respectively, in the ordinary rectangular co-ordinates.

Then $xy = K$ ....(5) which is the equation of the equilateral hyperbola. The constant K will depend on the kind and condition of the pavement, the velocity desired and the intensity of rainfall. Plotting up one branch of this hyperbola, and assigning several arbitrary values to K, we obtain a series of curves as in Fig. 1.

The line MM should be shifted to be the center line and the proper value of the constant K selected all to correspond with the particular results desired. Taking the line MM as the center line and making the other half of the section symmetrical, our theoretically correct cross section would be something like shown in Fig 2 B.



Figs. 2A, 2B and 2C.—Various Shapes of Crowns.

It goes without saying that such a shaped crown could have but two advantages, a uniform velocity of run-off and an effective separation of traffic lanes. But it is highly impractical.

The form in general use at this time is shown in Fig. 2A. It is flattest at the center, where the value of r is smallest. Consequently, the flat slope as well as the impossibility of obtaining perfect construction, cause water to stand in the center of most pavements, doing more or less damage. At the same time, in many cases there is so much slope at the edges that driving is difficult. This has led to the practice in many cities where study of the question has been made of using the least possible crown.

This brings us to the recommendation made in former times by J. Walker—that of using two straight lines joined by a short curve (Fig. 2C). So far as known to the writer, such a shape has not been used.

It will no doubt be argued that such a crown will be difficult to drive upon. If the planes were very steep, no doubt it would be, especially if attempting to drive in the center of the pavement at high speed. But city engineers in 13 central states replying to the questionnaire propounded by the 1922 American Society for Municipal Improvements' Committee 1-B indicate that they consider 0.3 per cent to 0.5 per cent as a minimum grade. Suppose their highest estimate be doubled. On a 1 per cent grade, if applied to the proposed cross section, a pavement 50 ft. wide would have a crown of 3 in., which is considerably less than common practice. It is believed that such a slope would not make driving difficult.

In conclusion, the writer does not offer the suggestion as a panacea for all paving ills. It is desired, however, to call to your attention our present practice of putting the flattest slope where the steepest is needed, and the steepest where not needed. By use of the recommended section, the "rolled" types of paving could be rolled with a little more scientific accuracy. The rollers being nearly true cylinders, there would be less tendency to form waves under these circumstances.

The conservative forces at work in our natures have prevailed against the radical, and we have followed the examples set before us in the past, frequently without question. It might be well to frequently read Sam Walter Foss' poem, "The Calf Path."

A Systematic Survey of Gravel for Roads

How a New England State Has Made the Discovery and Selection of Road Gravel a Scientific Process Told in a Paper Presented at Last Annual Convention of American Road Builders' Assn.

By WALLACE PURRINGTON,
Chemist and Testing Engineer, New Hampshire State Highway Department.

Five years ago, when work was started in New Hampshire on the testing of gravels, it was immediately seen that samples taken at random would furnish but very little information. Limits for the wearing qualities, for instance, could not be determined until a very comprehensive study of the whole state was made. The question arose, if any given gravel showed poor results, did this condition indicate the qaulity of gravel in other bands nearby?

Nature has a habit of doing everything according to some law. There was at the outset, then, reason to believe that the quality of gravel at any one place was determined by some of the laws.

For the purpose of this paper, we will consider gravel to be water worn pebbles mingled with sand or clay. Troughout New England and rather generally in the northern states, the deposits of gravel came from the melting of the great continental ice sheet at the close of the Ice Age. Since that time, some of these gravels have been redistributed by rivers or by waves and they may even still be undergoing rearrangement and alteration by these agencies.

The bed-rock of New Hampshire is composed of crystalline rocks commonly classified as igneous and metamorphic. We are neither blessed nor cursed with rocks of sedimentary origin. The results of the movement of the ice sheet can be seen today by the glacial scratches or "striae" still found upon the surface of exposed hard edges.

Areas of Different Types of Bed-Rock Mapped.—One of the first steps taken at the beginning of our survey was to make a map showing by colors the various areas occupied by different types of rock. This, and the direction of glaciation had been worked out by the State Geological Survey under Hitchcock, years before. Our success in future lines of investigation, was to a great extent dependent upon this very detailed knowledge of the bed-rock and glaciation which was available at the start.

How the Bed-Rock Map Is Used.—There are three well defined rock areas in the state; on the extreme west, running north and south and bordering on the Connecticut River is found a strip of slates or slaty schists; directly east of this area a loose textured granite is found and still further east, in the center of the state lies a great area of crystalline schist. Referring to our bed-rock map, we find that the scratches cut out by moving ice sheet, show a general northwest southeast direction. Our river systems, likewise, flow in a general southerly direction. Let us consider then what our problem becomes. The ice sheet moving into the state on its journey southeastward picks up great quantities of the slate of that district. As it strikes the granite belt it gathers more and more granite which dilutes the slates. As the distance increases the slate content becomes almost negligible. In this case, the slate is an extremely soft material and the granite is but little harder. The result then, is a varying mixture of two very soft rocks and as a consequence, we should rightly expect to find a gravel with but poor wearing qualities. Let us trace the course of the glacier still farther east into the crystalline schist area. Here we have a rock which at one time was sedimentary but which was subsequently hardened by heat and by becoming soaked with underlying granite masses The gravel from this area proves to be highly resistant to wear. It is obvious, that the ice sheet leaving the soft slate and granite begins to pick up the border schist and as a consequence, we find that the further southeastward we go, the stronger the gravel becomes.

The melting of the ice sheet concentrated and sorted the rock fragments. The condition resulting was dependent upon the amount of flow of water at any one point. Where a glacial river containing an overburden of material flowed through a narrow canyon or tunnel in the ice sheet, we find an easker or steepsided ridge. Where the material collected under more irregular conditions at the side or front of the glacier, we find kames. When the outflowing rivers discharged into lakes or the sea deltas and washplains were spread. The more force that the water had, the larger were the materials which were transported. We find then, that our coarser materials are in the eskers and kames and the more sandy-gravels are in the deltas and washplains.

In a study of gravels, there are certain geological facts that must be known; the nature of the bed-rock at any point, the nature of the adjacent bed-rock on the side from which the great glacier came and the topographic features.

Determination of Composition of Gravel by Stone Test.—Some of the most valuable information found by the survey of New Hampshire gravels was obtained by making counts of the stone composing each gravel, i. e., the percentage of granite, slate, schist or other rock type. For this purpose, at least 100 pebbles, taken at random, were counted and the result computed. By such a quick and simple measurement of competition it is quite possible to draw conclusions as to the strength of the gravel and so of its value for road purposes. Ordinarily there is not, in any given town, a great difference in the quality of gravel to be found. There are indeed, differences in the proportion of sand, pebbles and bobbles. This is true of the material found even at different points in the same bank. If, when gravel deposits were formed, the force of water with its load of material had been uniform, we might have had homogeneous deposits. Such was not the case where eskers and kames and other glacial gravel deposits were built, consequently, one hardly knows what is to be found in any part of a deposit that is not visible. To the writer's mind any sample submitted to a laboratory for grading from gravel deposits like these is a mere waste of time. There may be some merit in testing a river or washplain gravel in this matter for these are more uniform. Other investigators have reached the same conclusions regarding the absurdity of laboratory grading of samples from glacial gravels. An intelligent manipulation of any pit will give better and more reliable results than any arbitrary grading system that may be devised.

Knowing from field studies, the nature of the deposit, the composition of the gravel as revealed by the stone count, the amount of gravel available and its probable grading, the testing laboratory has to pass final judgment upon its value to support traffic. The work carried on by our survey covered nearly 500 samples of gravel, taken at points which represent all the leading geological conditions. A comparison of the laboratory results was made with the count of the stones in every case.

The test used was the Rea modification of the standard Devel Abrasion Test, which modification consists in the addition of six steel bells, used as an abrasive. For the bedrock, the standard Devel Test was carried on. The actual figures obtained were of course different but the relation between the two tests were similar. In other words, if we found that a certain bed-rock showed a high percent of wear when tested by the Standard Method, we should expect a similar high percent of wear using the Modified Test on gravels composed chiefly of that type of rock.

The New Hampshire Specifications for Gravel.—As a result of the investigation, the State Highway Department has adopted the following as a specification:

"General.—Gravel shall be composed of fragments of hard, durable rock, the individual particles showing reasonable uniform resistance to abrasion, together with sand or clay or other binding material.

Physical Properties.—The gravel shall meet the following requirements:

Class A Gravel—Percent of wear not more than 7.

Class B Gravel—Percent of wear 7-10.

Class C Gravel—Percent of wear, 10-15.

Class D Gravel—Percent of wear, over 15.

Class A and B gravels may be used for either or both base and surface courses; Class C may be used for base course only; and Class D may be used on special written permission of the commissioner.

This specification is applicable to our conditions. It has been devised after noting the actual road making values of various gravels. It is purely arbitrary, but has limits which we can meet in New Hampshire, but it is appreciated that these values may not be feasible elsewhere.

There can be no question of the value to any highway department of a detailed survey of road materials. If the material in any deposit proves to be inferior, it stands to reason that there is a cause for the inferiority. The thorough knowledge of these causes, whether they are conditions of bedrock or glacial geology should be obtained. For this, the employment of a competent geologist is absolutely necessary. No well organized testing laboratory should be without one.

The Testing Laboratory as a Clearing House.—The testing laboratory should become a clearing house of information to which the engineer may refer, as often as new construction projects call for the selection of material anywhere in the state. Turning to the colored geological map the engineer sees at once whether the conditions of bed-rock and glaciation are such as to favor the occurrence of strong or weak gravels. Colored pins on the map tell him the locations and general quality (in terms of strength) of all samples already collected and studied from that district. A number on each pin indicates the laboratory test number of that sample. Reference in the files, to the cards bearing these numbers affords the more exact record of the stone counts and the abrasion tests. These facts enable the engineer to turn in the right direction in his search for gravel, avoiding loss of time through search where gravels are weak and looking rather for banks where stronger gravels must be expected. If his own knowledge of occurrence of gravel deposits there is incomplete, he may call in the geologist for consultation or for a special field reconnaissance. In this way, the best sources will not be overlooked. Samples are then collected from the more promising banks. Finally, the tests run on these samples by the laboratory will mainly determine the choice. Questions of amount available, relative economy of operating different banks, etc., will be left to the highway engineer and the administration officer. In short, the process of discovery and selection of gravel is scientific instead of haphazard.

How an Illinois County Maintains Its Highways

Methods in Bureau County, Described in Paper Presented at 1922 Convention of Illinois County Superintendents of Highways.

By C. L. MELCHER.
County Superintendent of Highways, Princeton, Ill.

Bureau County is one of the rather large size counties in Northern Illinois, having an area of 881 square miles and a total road system of 1,482.2 miles, with 296 miles of state aid system. The county has considerable variety as to soil and topography, there being almost any condition in Bureau County that will be met in the State of Illinois. We have some very hilly country that is mostly clay, with some timber covering, and we have the typically rolling prairie and there is also some swamp land, hardpan and blow sand.

These conditions are met with on the state aid and bond issue systems in Bureau County and some of them are difficult to overcome. Probably the heaviest earth work section on the Chicago-Springfield road is in Bureau County between Spring Valley and Depue. Grades of 7 per cent were found necessary by the Division of Highways to overcome the heavy hills in that section.

Previous to Jan. 1, 1921, the county had done the usual amount of grading as done by the several townships, had met the allotments of the state in the construction of about 9½ miles of concrete and brick pavement on the state aid system and had advanced funds for the construction of a section on the Chicago-Springfield road. No plan for maintenance of earth or gravel roads or the improvement of the state aid system had ever been presented to the people of the county nor had any such maintenance been done by the county.

Special Tax for Maintenance and Reconstruction.—In the summer of 1920 we conceived the idea of maintaining and reconstructing the state aid system outside of the bond issue system in Bureau County and for the purpose of carrying on this work for four years, the board of supervisors passed resolutions asking for a special tax for this work under authority of Section 27 of the County's Act of the Illinois Statutes. The rate of tax for this work was placed at 60 cts. on each $100 of assessed valuation and was presented for a period of four years with the idea that at the end of that term conditions would be somewhat different and construction and maintenance plans would then be revised for carrying on further work. This tax was calculated to yield about $215,000 per year, or a total of $860,000 in four years.

It was not expected, at that time, to do any extensive improvement on the sections of the state aid system that were already well surfaced with gravel, but to give speedy relief and improvement on the worst sections by grading, draining and gravelling. The tax was voted with a majority of about 3 to 2 and the Board of Supervisors levied the tax and began to plan for the first year's work.

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*Tests to be made in accordance with the method described in U. S. Department of Agriculture Bulletin 555, Page 301.

Revision of the State Aid System.—At the same time that the plan was presented for the maintenance and improvement of the state aid system of the county, a resolution was presented providing for a revision of the state aid system in order to give a better engineering location and as a consequence better connections between the several towns and communitis of the county, especially with the bond issue system. The routes were made in such a way as to give the several townships that were not fortunate enough to be on the bond issue system a direct and quick connection to that system and also to connect consolidated schools, country churches and community centers.

A county system of highways is a secondary system of roads and should be located and improved in such a way and in such order that the so-called through routes may be of greater service to each county and community. An analogy could be drawn between the bond issue system and the state aid system of the several counties and a double-track main line railroad and its branches. We cannot all live on the double-track line, so we must have branches or feeders to these main lines that are of real service, or, in other words, will handle the local traffic for 365 days of each year. We will then begin to have real "farm-to-market" roads and our highway system will really begin to function. People living in townships off the Bond Issue System are going to demand that kind of service.

Patrol System of Maintenance.—We began our work in March 1921 by first establishing a patrol system of maintenance on the entire county system. Men were selected who seemed to be able to work by themselves without too much close attention or check on the time they put in on the work. These men were not teamsters but a great many of them were men who had farmed and knew road conditions where they were employed. They have given us, as a whole, very good service and most of them will be employed in 1922. Their experience and training is worth money to us.

We employed 27 men on 230 miles of road with the sections having a mileage of from 7 to 11 miles. We have found that the proper size section is about 7½ or 8 miles where there is a fair amount of traffic. On an earth road a partolman will get behind in maintaining his section when we have a succession of showers at one or two days interval. This is true even in weather when the roads dry very quickly on the morning following the shower.

How the Patrolmen Work.—Some patrolmen like to tackle the worst mile first and give that a thorough smoothing before taking the rest But that system is not correct. They should on an ordinary width of roadway, travel over the entire length of the section on one track and return the same day by widening that track. This will give within a few hours, one smooth path for traffic. The next day they can cover the other side of the roadway and will probably need an additional day to shape up spots that have dried later or that were badly cut up.

An earth road is a wonderful road when it is smooth and the patrol method of maintenance is about the only way you can keep an earth road smooth. The continual working of the surface seems to case-harden the top and it becomes very durable. The ordinary rains and the milder seasons of the year do not affect it greatly if it is properly graded. We have found that our earth roads that were patrolled were fit for use during the summer season a couple of hours after a rain. Even the graded sections seem to shed the water very easily because there was no place for any water to stop and soak up the surface or damage the subgrade. However, an earth road will not stand such a prolonged wet spell as we had last fall. They will simply become so thoroughly saturated that they are of little use.

Maintenance of Gravel Surface.—The patrol system of maintenance is the only reasonable way of keeping a gravel surface in condition for travel. Our old gravel roads when we took them over were very rough and full of holes and stones. We scarified those roads at a cost of from $30 to $50 a mile and the patrolmen raked off the stones and worked the loose gravel into the proper shape. The worst kind of a gravel road can be very effectively cured in this way and put in such condition that there seems to be a new surface.

Where gravel is thin, it should have additional material put on at that time. The sacrificing should be done to the depth of the deepest hole and all material should be torn loose with a scarifier and then thoroughly worked over with a blade grader. Where old gravel has had surface treatment such as oil, tar or bituminous material, the working with a blade after scarifying will break up the lumps and the road can be reshaped easily. However, after the big blade has done this work a patrolman should finish the job.

The continual moving of the materials on top with a patrol grade as traffic is breaking up a portion of that old crust, serves to put the surface in a wonderfully smooth condition. The grader puts the real finish on that job. You will have to remove some teeth from the scarifier in an old oiled gravel road because it is very tough and very hard to break up. The tractor and scarifier have work up to their capacity. To maintain a gravel road properly you need loose material on the top that is moved back and forth with the patrol grader. In other words, the surface cannot be kept smooth until it is, as we say, alive. A gravel surface that packs and leaves no loose material is very hard to patrol because the only way to fill holes or depressions is to cut loose some of the packed material or scarify the surface. After a rain the material that seems to have been rather sandy or lacking in binder will bind with the old material and form a fresh surface for travel.

We found further, that the two-horse, four-wheeled grader with the 6-ft blade is the best machine or tool for patrol maintenance. However, there is considerable work on most sections of road that should be done by hand. The patrolman cannot make a good road with just a patrol grader He will have to exercise some of his muscle. On hilly sections of road the ditches are either cutting or filling and they must be maintained and the water kept from flowing down or across the roadway or from undermining the shoulders. In cuts or on side hills the earth is continually moving into the ditches from the banks and the patrolman must care for his shoulders and clean the ditches before they become clogged or the water damages the roadway. In the heavier maintenance a large blade grader can clean those ditches very cheaply and effectually and also straighten or deepen the outlets.

The quickest way to get any road in a useable condition is to establish a patrol system of maintenance. A patrolman can simply work wonders with almost any road. At the beginning of our work we found that everybody wanted service of the large blade graders but this demand was lessened when a partolman had been on the work three weeks or a month. In addition to the patrol grader, we furnished our men common slip scrapers and they furnished their own small tools.

Road Grading With Tractor Drawn Graders.—Without doubt, the tool or machine most misused in highway work is the blade grader. The newer type of blade graders are a real road-building machine when you have properly trained operators. Bureau County purchased four tractors and four 12-ft. graders to begin the work of bettering the county road system. Two scarifier attachments were bought for these graders and our most economical and efficient work was done with these machines. The right of way on our roads in Bureau County averages from 50 to 66 ft. in width. With the old style of grading there seemed to be too much right of way and a great many of the farmers began to move their fences in the road

On some roads there was considerable brush, stumps, trees and telephone poles on the road side of the ditch line. Where we encountered brush, stumps and trees, we used dynamite and the tractor to remove them and then cut our ditches straight through. We have staked our ditch lines at 40 ft. center to center by setting laths on what may be called permanent ditch lines. The center line was carefully placed as possible with relation to fences and the present right of way as it would be placed for paved road. Then the ditch stakes were set with a transit 20 ft. each side of the center line, making a clear road way after construction with the blade grader of about 30 ft.

We graded on county work approximately 70 miles of road and 20 miles on township roads. This was in addition to the scarifying of 70 miles and other maintenance of approximately 40 miles of road. Where the approaches to bridges and culverts were narrow and there were short hills to cut off or bad holes to fill in straightening the alignment, we employed teams to remove the earth longitudinally. The blade then cut the ditches and balanced up the earth work on the entire roadway. Our ditches are from 24 to 36 in. deep, with occasionally a somewhat greater depth where we wished to raise the grade or have more waterway in the ditch. Some of these old roads were lower than the adjoining fields and that meant moving from 2,000 to 3,000 yd. of earth to the mile with the blade grader.

The Road Sections.—Our road sections were built to give us approximately 6 in. of crown on the 30-ft. roadway with the 1½ to 1 slope on both sides of the ditch and about 15 in. width on the bottom of the ditch. This was modified where we worked in sandy sections or on hillsides. We have one piece of swamp land or slough that they said we could not grade. It was below the level of the fields and the soil was yellow and blue clay and just plain mud. We graded that in July and the clay brought up from the ditches has made an almost impervious surface. It seems to bear the weight of traffic better than any other section of road we have and it is cut up less after heavy rains. Our theory is that we have simply brought up material that formed a waterproof coat on the top of the old soil. Similar conditions have been observed in other places where hard pan or muck was uncovered in the ditches and we have found that the mixture of this material with ordinary top soil forms a first-class surface. It is better than either material would be alone.

Our four outfits worked from March 20 to Nov. 1 without a stop except such as conditions imposed upon us. We really carried on the work too long in the latter part of the season, but the demand of the townships kept us going.

Points on Earth Road Grading.—In grading an earth road, set stakes with the transit on the permanent ditch line and then the first round of the grader, cut the sod far enough back from the ditch line to clear the back slope of the completed ditch. Cut this sod with a light cut and move it into a line under your new shoulders. Then by successive rounds cut your ditches and move the loose earth on and over the entire roadway. To make the best job your ditch cuts should be made in the manner we speak of as stair-stepping. That is, make the first cut a couple of feet outside of the ditch line, being careful to get the cuts straight and parallel to the line of the new ditch. The second cut for deepening the ditch should be made from 6 to 9 in. toward the road side of the first cut. The third and following cuts are made in the same manner, spreading each layer of fresh earth over into the roadway and building up the shoulders. When the ditches are deep enough, put on your back sloper and trim the back slope and clean out the bottom of the ditch. It will take two rounds of the grader to clean the ditch properly and cut the back slope. This last material goes upon the shoulders of the road and is spread from the shoulders to the center line of the road. On most of the old roads that had an excessive crown, we have not raised the center of the road. All the earth we have cut out of the ditches and from the back slope has been used in building up the shoulders to that old crowned road and giving the road a 6-in. crown.

When you have completed a mile of road in this manner you will find that it is very loose. That is, the soil you have cut from the ditches and back slope is more or less like new cultivated soil in a field or like a garden. To finish and keep it smooth under traffic, put on a patrolman immediately. He should continually work that fresh surface under traffic and help fill the minor depressions as they appear and dress up the surface. In fact a patrolman completes the road or changes it from a fresh graded roadway to a finished subgrade.

Costs.—The team work has amounted on many sections of road to more than the work of the tractors and blade grader, while the blade certainly moves many times the amount of earth in cubic yards. Our blade grader work has cost us, not counting the item of depreciation of equipment, all the way from $100 to $400 per mile. The sections of least expense were in a rather sandy country where we could not cut and did not require a deep ditch, and the heavier cost sections were where bad weather was encountered or conditions such as stumps, trees and heavy grading. It is the amount of earth you move with any machine that counts in the cost of the road. The yardage of earth moved by the blade grader has been estimated at from 1,000 to 3,000 yd.

We have found it not necessary in this work to close any roads during construction, but have kept them open and the fills smooth in order to get the benefit of such traffic as we had, to help pack the roadway. In the grading of our country roads, we have cut 23 corners, to a minimum radius of 300 ft. This was done at the same time we did the other work, so the teams and blade could shape up those curves and make them a part of the new road.

We have banked the turns at about 1 in. to the foot, and find them to be very fast. Some of our reckless drivers have taken them at upwards of 50 miles an hour. The first corner was rather difficult to buy because people did not think it necessary for safety and thought it gave the people a chance to speed up on the corners, but of late, the township commissioners have been coming to me and talking about some of their corners that people complain of now, as being unsafe. While we have not yet worked out a standard for the connection of the township roads with our county roads, nor township roads with county roads, it would seem that something could be done either to keep the corners clear or to round them to a smaller radius, say probably 100 ft.

Excess Sand and Pit-Run Gravel in Concrete Pavements

The use of pit-run gravel has been found economical in many cases in proportioning mixtures of screened sand and gravel containing various ratios of sand and gravel. In a paper presented last June at the annual meeting of the American Society for Testing Materials, Mr. R. W. Crum, Engineer of Tests of the Iowa Highway Commission describes the use of this method of proportioning upon 122 miles of pavement laid under supervision of the Iowa State Highway Commission during 1920 and 1921, as compared with 65 miles in which the proportions of 1 : 2 : 3.5 by volume were arbitrarily specified. Pit-run gravel was used in 35.43 of the 122 miles. The paper follows:

The necessity for the use of relatively large ratios of sand to coarse aggregate arises from the fact that the entire gravel supply of Iowa contains from 50 to 85 per cent of material finer than the opening in a No. 4 sieve (sand). Inasmuch as the general construction demand for sand is not large enough to absorb the excess of sand, proper engineering methods must be employed to prevent the waste of vast quantities of valuable material. The proper economical and engineering solution of the construction problems in the State of Iowa require the use of all our available materials. It appears probable in connection with highway construction that after the other demands for sand are satisfied that an aggregate containing half sand and half coarse aggregate will be in rather general use.

The comparisons and conclusions based thereon are base upon the tests of specimens made during the progress of the work. Two 6 by 12-in. cylinders and two 8 by 8 by 5-in. blocks for the Talbot Jones wear tests were made each day, and stored along the road for curing under substantially the same conditions as the pavement itself. Information as to the uniformity of the mixtures was secured by washing the cement from a sample of the concrete from the same batch as the cylinders, and running a sieve analysis upon the aggregates.

It is to be expected of specimens and analyses made in this way under field conditions that there will be considerable variation in individual results. However, if a considerable number of specimens are used, it is reasonable to expect that the averages will actually represent the qualities of the concrete and that the variation in individuals will give some measure of comparative uniformity.

An addition to the specimens made during construction, cylinders were taken from the pavement on several projects after the pavement had been in use from 6 to 12 months. In each case the cores were taken from a spot in the pavement which was represented by specimens made during construction.

Uniformity of Composition.—Other qualities being equal, the principal objection to the use of pit-run gravel has been the fancied lack of uniformity in the resulting concrete. It is true that these experiments show that there is a great opportunity for improvement in the uniformity of concrete mixes, but, it is rather surprising to note that the mixtures of screened aggregates are no better in this respect than put-run gravel mixtures, and often not so good when the pit-run gravel is handled in the most advantageous manner.

Laboratory Investigations. — Laboratory tests were made to verify the application of the "sand" method of proportioning on the strength of concrete in transverse tests, and also to study the extension of the method to cover mixtures of sand and crushed limestone. The results show the equivalent transverse strength can be secured by this method and that the method applies to the use of crushed limestone.

Twelve proportions, three consistencies and two types of materials were used, ten specimens being made for each mixture. Six hundred and eighty specimens were made and tested at the age of 28 days. Storage was damp sand. The beams were all 4 by 8 by 30 in.

Assumption on Which Specifications Are Based.—In view of the experience recorded herein, the Iowa State Highway Commission has based the standard specifications for single-course concrete pavements upon the assumption that it is possible to so design and construct concrete pavements with varying cement, sand, and coarse aggregate contents that the results will be in as close agreement as may be expected from the arbitrary mixtures in common use. Furthermore, the more heavily sanded mixtures have at least two important advantages.

1. It is quite generally accepted that if the voids in the coarse aggregate are more than filled by the cement and sand mortar, the internal grading of the coarse aggregate will have little effect upon the strength of the concrete. Such being the case with the mixtures under discussion makes it possible to use certain aggregates which might not be suitable for use in the more common mixes.

2. In proportioning mixes of high sand to coarse aggregate ratio, the amount of the cement should be based upon the maximum amount of sand to be expected; then, when the amount of sand at times becomes less, the high ratio of cement to sand will more than compensate for the variation. For instance, if the proportion be based upon 70 per cent of sand, and the percentage of sand falls to 60, the mix would have more cement than the 60-per-cent sand requires, and the variation would not be at the expense of the strength of the concrete. As shown by the records of actual sieve analyses, considerable such variation is to be expected. Mixes such as the usual 1:2:4, which are intended to just fill the voids in the coarse aggregate do not provide any such factor of safety and most of the variation is, therefore, more serious.

A most important factor in the successful use of unusual and varying mixes is the careful and accurate control of the details of construction. This requires two full time inspectors upon the job in addition to the inspection and tests made upon each unit of shipment by the material inspection force. One inspector is constantly on duty at the measuring and proportioning station and the other supervises the placing and curing of the concrete.

There are some indications that the temperature stresses in mixtures containing above 60 per cent of sand are higher than usual, as evidenced by the number of transverse cracks in the pavement. Data on this point are not now available but the point is under investigation.

Iowa Requirements for Concrete Pavement.—The following are the requirements specified by the Iowa State Highway Commission for proportioning concrete for concrete pavement: When a screened or unscreened gravel aggregate is used for either type of pavement, the ratio of cement to the aggregate by weight, shall be in accordance with the accompanying table. The mixtures may be made by weight or by measure. When volumetric measurements are used, the proper ratios to use will depend upon the weights per cubic foot of the materials and will be established by the engineer. A bag of cement weighing 94 lb. net shall be considered to contain one cubic foot.

If unscreened gravel aggregate is used, either for concrete pavement construction or for concrete base, the proposed source of supply must be approved by the engineer (Highway Commission) before any material is ordered. Further, an unscreened gravel aggregate must be used from stock piles containing at least 1,000 cubic yards in order to insure uniformity of proportions of the fine and coarse aggregate, and to prevent undue segregation of the fine and coarse particles.

PROPORTIONS FOR SCREENED AND UNSCREENED GRAVEL AGGREGATE.

Sand in aggregate, per cent by weight.	Proportion by weight. Pit-run gravel	Cement to gravel. Screened gravel.	Approximate quantity of cement bbl. per cu. yd.
33	1:5.18	1:1.71:3.47	1.6
34 to 40	1:4.84	1:1.93:2.91	1.67
41 to 45	1:4.59	1:2.06:2.53	1.74
46 to 50	1:4.34	1:2.17:2.17	1.80
51 to 55	1:4.10	1:2.25:1.85	1.87
56 to 60	1:3.84	1:2.30:1.54	1.95
61 to 65	1:3.60	1:2.34:1.26	2.04
66 to 70	1:3:35	1:2.34:1.01	2.15
71 to 75	1:3.10	1:2.33:0.77	2.26
76 to 80	1:2.86	1:2.29:0.57	2.30
81 to 85	1:2.61	1:2.22:0.39	2.53
86 to 90	1:2.36	1:2.12:0.24	2.71
91 to 95	1:2.12	1:2.01:0.11	2.89
96 to 100	1:1.87	1:1.87	3.13

Cinder-Asphaltic Oil Demonstration Roads

So as to demonstrate in an actual way a practical method of constructing and maintaining the side roads of the State, the New Jersey State Highway Department has this year employed a novel and effective plan. The Trenton Fair, which is held annually in the State Capital, attracts thousands of people from all parts of the State, including farmers, highway contractors, road engineers and superintendents, township committeemen, and many others actually interested in highway work.

In order to take advantage of the opportunity of demonstrating an approved method of maintenance to this class of people, the State Highway Department this year constructed a stretch of demonstration road. This sample road is made of cinders from soft coal. After the cinders were dumped and spread, they were rolled with a light tandem roller to effect as much consolidation as possible. The next step was to apply Texaco road oil containing approximately 55 per cent of asphalt. This road oil served as a dust layer and also as a consolidation and binding medium. After the road oil was applied at the rate of ½ gal. to the square yard, the roller was again run over the entire surface.

The State Highway Department points out that such a road would not serve as a main state route, but that it demonstrates a method for keeping side roads made of earth, sand, clay, cinders and so forth, in good condition.

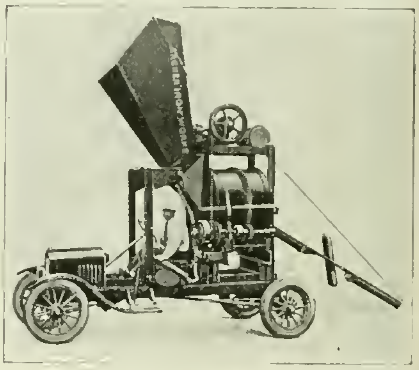
The use of coal cinders and asphaltic road oil as materials to form the surface of side roads has demonstrated its practicability in several different localities. The village of Southampton, L. I., has had particularly good results from this procedure. This village employs this method on bridge approaches on its side roads,

A $35,000,000 Private City Planning Project

It is stated that the largest single piece of city planning by private enterprise ever undertaken in this country for permanent development will be the new Palos Verdes Project in Los Angeles, now being financed through nation wide underwriting. This project includes an acreage of 16,000 acres at the southwest corner of the metropolitan area, part of which is on the ocean shore where a new suburb, similar to Roland Park or Forest Hills, will be built. It will include a greater number of low-priced homes than such projects have in the past. A total expenditure of $35,,000,000 is expected.

New Mixer Mounted on Truck Chasses Takes Power from Truck Motor

A mixer mounted on a Ford truck chassis and taking its power direct from the truck motor has been placed on the market by the Archer Iron Works, Western Ave., and 34th Place, Chicago. The mixing drum is the Standard Archer 7 S one bag mixer. The lifting arms of the side loader permit the loose materials to be held at the mouth of the loading hopper, ready for discharging into the drum itself. In moving from one job to another, the side loader can be readily unbolted and hooked on the rear of the truck itself. by means provided. The Archer Ford paving and building mixer is equipped with side loader, automatic water tank and 9 ft. paving chute with gate openings as standard equipment. The mixer frame is simply clamped to the chassis with "U" bolts, allowing contractors to adapt this mixer to Ford trucks they now have in service. The weight of the mixer complete, with loader, approximately 2500 lb. The Archer Ford mixer is also furnished as a low charging mixer. On this machine the mixer drum is set directly on the truck chassis, and it is equipped with loading platform for charging the materials into the drum direct with wheelbarrows. The side loader, water tank and paving chute is not provided. This machine is also fitted with the 7-S one bag mixer drum.



Archer Ford Concrete Mixer.

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Waterworks and Hydraulics Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
- (a) Roads
- (b) Quarries and Pits
- (c) Streets
- (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
- (a) Water Works
- (b) Irrigation and Drainage
- (c) Sewers and Sanitation
- (d) Waterways

Railways—3rd Wednesday
- (a) Steam Railway Construction and Maintenance
- (b) Electric Railway Construction and Maintenance
- (c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures

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How Can Waterworks Superintendents Secure Adequate Salaries?

City engineers of cities having a population up to 30,000 seldom receive more than $250 a month, the average being about $200. Superintendents of water departments usually receive less than city engineers, so it is reasonably certain that few water works superintendents in towns of less than 30,000 people receive as much as $200 a month. Not long ago the water works superintendent of a city of 25,000 told the editor that his salary is $150 a month, and he has charge of a plant that cost a million dollars. Yet in that town day laborers receive $4 a day and skilled mechanics receive $7 a day which is $1 more than this head of a million dollar water works receives. Were this an unusual case we might ignore it, but unfortunately it is typical of both the injustice and the shortsightedness of the average city council in its treatment of the head of city departments. The injustice is too apparent to require comment. The shortsightedness perhaps needs some discussion.

While it is true that many a water works superintendent remains at his post in spite of the inadequacy of his salary, a little inquiry discloses the fact that the average superintendent is disgusted with the treatment that he is receiving. And it needs no argument to prove that a disgruntled employe rarely does full justice to his job. He may try to overcome his disgust at the inadequacy of his income, but try as he will, that disgust will affect his efficiency. We believe that if the head of a city department receives, say, $150 a month less than the importance of the position would warrant the city in paying him, his disgust at his treatment by the city will cost the city several times $150 a month. This will occur not because he consciously tries to "get even" with the city for its niggardliness, but because he unconsciously fails to do all that he is capable of doing as a manager.

There are few city councilmen so inexperienced that they can not be shown the shortsightedness of a policy that involves under payment of the heads of city departments. But the trouble is that few attempts are made to persuade city councils that a liberal policy as to salaries of executives is a truly economic policy. The daily newspapers rarely comment on such matters. The tax payers say nothing. The boards of trade remain silent. Even engineering societies remain equally dumb. So there is left no one to suggest reasons why the water works superintendent should receive a better salary, unless it is the water works superintendent himself. But he knows, too well, that a man who asks for an increase in his own salary usually talks to ears that are plugged with indifference, so he conserves his vocal cords.

Every water works superintendent should join a water works association, and should urge the association to co-operate with other organizations and societies in educating city councils to appreciate the importance of the economic law that payment for service should be proportional to the responsibility involved and to the economics effected.

At What Depth Can Cool Water Be Secured in Summer?

Cool water is undeniably more palatable than warm water. Water intakes can often be located at sufficient depth to secure cool water even in the hottest weather. Probably very few civil engineers or waterworks superintendents know what depth must be attained to secure water whose temperature is practically constant throughout the year. Hence the following facts should prove of interest, and possibly of economic worth.

At the request of the editor, Fred W. McElman, C. E. of Bellingham, Wash., took temperatures in Lake Padden and Lake Whatcom during July and August. A recording maximum and minimum thermometer was used.

Lake Padden is a 110-acre lake that supplies South Bellingham, and its greatest depth is 45 ft. at low water The intake is 12 ft. deep. During August the temperature at the intake was the same as at the surface, and averaged 64 degrees. This also was the temperature at a tap in the center of town, two miles from the lake. The temperatures at different depths were as follows:

Depth.	Aug. 14.	Aug. 28.
Surface	63 degs.	66 degs.
25 ft.	62 degs.	63 degs.
30 ft.	61 degs.	61 degs.
35 ft.	52 degs.	54 degs.
45 ft.	51 degs.	52 degs.

Lake Whatcom is a very deep lake, 10 miles long, that supplies North Bellingham. On Sept. 3 its temperatures were as follows at different depths.

Depth.	Temp.
Surface	64 degs.
30 ft.	53 degs.
35 ft.	59 degs.
40 ft.	53 degs.
85 ft.	50 degs.

At a tap in the center of the city, about 4 miles from the lake, the water was 56 degrees, indicating that it had risen 6 degrees in flowing through the main.

These records indicate that at a depth of 35 to 40 ft. the temperature of the water drops suddenly, and is about the mean annual temperature.

It seems to us that there are two economic advantages to be gained by drawing water from a reservoir at a depth of 35 ft. or more: First, the greater coolness of the water secured from this depth may lead to less waste of water in the effort to cool it by allowing it to flow from the tap. Second, less ice will be needed to cool the water to a desirable temperature.

In a cold climate water taken from a depth of 35 ft. or more will be many degrees warmer than water taken from nearer the surface. This should insure fewer instances of frozen service pipes.

It remains to determine what temperature changes occur in water between the intake and the taps. This, of course, will depend upon the length of the mains, upon the character of the soil, upon the depth of the main, upon the difference of temperature between the water in the pipe and the soil surrounding it, and upon the velocity of the water in the main.

Water at a temperature of 60 degs. is very palatable, but water is preferred by most people when its temperature is 10 degrees lower; then it tastes like water from the "old oaken bucket."

We suggest to water works men that in the future more consideration should be given to the question of providing water at a temperature between 50 and 60 degrees, wherever the cost of doing so is not excessive.

Engineering Societies Should Support the City Manager Plan

Ten years ago "the city manager plan" was first put into effect. Today more than 250 cities are operating under this form of government, namely, government composed of a board of directors known as city commissioners and an executive known as a city manager. Almost every student of the results secured by this form of government pronounces it to be far superior to other forms. Woodrow Wilson says: "I regard the commission-manager plan of municipal government as a marked advance over any plan hitherto tried in this country, from the standpoint of both efficiency and democracy."

At last the administration of city affairs is becoming a profession that is attractive to able men. And it is noteworthy that many city managers are civil engineers who have been city engineers or assistant city engineers.

In small cities the city manager can act not only as a general executive but as city engineer. This reduces the administrative expense, while at the same time providing a scientifically trained mind capable of weighing the economic factors that enter every problem of administration.

A splendid feature of the city manager plan is that the smaller cities act as training schools for managers for larger cities. Many a city manager has received such attractive offers from other cities that he has resigned to accept larger responsibilities. This is as it should be, for while it often results in the loss of a good manager by a city, it serves to spur the ambition of every city manager to win the larger prizes for efficient management. In short, it applies to city management the spur that has been so long effective in business management.

If engineering societies were fully awake to all the possibilities of service to their members and to the public, they would be the most active propagandists in favor of the city manager plan. But unfortunately a century of professional precedents can not be overcome in a twinkling or even in a generation, so we have yet to hear of any aggressive and persistent effort by any engineering society to persuade the public to adopt the city manager plan. We do not despair, however, for engineering societies are more and more giving attention to public matters in which they believe themselves competent to guide public opinion.

The Six Greatest Men in History

To The Editor: Are you not rather severe on H. G. Wells in your article of July 5? Though it may be impossible to judge who are the six greatest men in history, there is undoubted interest and instruction in speculating on the question. For example, Mr. Wells' assertions drew from you opinions on the history of science that interested me and, I am sure, hundreds of other readers. You say that Jeffries was a great pugilist, Gotch a wrestler, and Kelly a great sprinter, but that it is impossible to decide which of the three was the greatest. Very true, but Mr. Wells' problem, as stated by himself, was to select the six men who have most changed the world by starting people to thinking along fresh lines. That is quite a different inquiry from deciding which of three differently-specialized athletes is the greatest, and it seems to me that the inquiry is legitimate and reasonable.

The main part of your criticism was concerned naturally with the two scientists included in Mr. Wells' list, Aristotle and Roger Bacon. You depreciated these two, and seemed inclined to favor Leonardo da Vinci, Copernicus, Galileo, Kepler, Francis Bacon, Newton, and Archimedes. I agree with you that Roger Bacon was not one of the very greatest of scientists, although I think he was greater than Francis Bacon; and I agree that Galileo, Newton, and Archimedes rank at the top of such a list—with the addition perhaps of Darwin and Pasteur, rather than of Leonardo, Copernicus, and Kepler. But I believe that you underestimate Aristotle. Some difference of opinion exists of course as to the place of Aristotle in science, but the authority that you quote, Whewell's "History of the Inductive Sciences," is somewhat antiquated. A good deal of research and interpretation has been done since Whewell ground out his ponderous opinions: the book was published in 1837. Aristotle's physics, as you say, is vague and incorrect, but his encyclopedic systematizing of knowledge three centuries before the Christian era is one of the wonders of history, and he was the founder of zoology. The more that modern scientists learn about the science of life, the more they are amazed at Aristotle, a man interested also in poetry, politics, and half a dozen other fields, could have known so much without the resources of libraries and laboratories that we enjoy today. To a great extent he had to lay his own foundations, because little had been written on science or method before his time. He set men to thinking systematically and he inspired countless others by his example. That his pronouncements were taken too literally and too rigidly during the later Middle Ages, and thus discouraged and stifled original investigation was not his fault. Literally he was for centuries "the master of those that know," the first notable organizer and systematizer of knowledge, and one of the great "know-it-alls" of all time. I say this, although personally I prefer Plato to Aristotle as a philosophical influence.

P. B. McDONALD.

New York University.

Specifications for Conventions

While the following memoranda were prepared especially for library conventions, they are intended to serve as general specifications for conventions of almost every description:

I. Convention Committee (VI, XI-XIII): Three members, the personnel changing at the rate of one each year. Ex-officio representation on

II. Three Primary Sub-Committees: Program (III-VII); Hospitality (VIII); Follow-up (IX); and on Joint Committee on General Information (X).

III. Program Committee: Two main objects: (a) to arouse enthusiasm; (b) to advance technical interests, seeing that

IV. Chairmen of sessions promote discussion of technical presentations; hence, providing for

V. Advance Distribution of Technical Papers (when practicable), each of which should contain a summary to facilitate discussion.

VI. Treatment of addenda or of any changes in a published program, technical or social (a responsibility of the convention committee, also, which should have in mind the interests of all.

VII. Exhibits should be in charge of a special committee and be co-ordinated, as far as practicable, with the session papers.

VIII. Hospitality Committee: Responsible (through various sub-committees, if necessary) for matters that concern transportation, housing, introduction (for which there should be a large subcommittee), excursions and, generally speaking, the pleasures of the convention.

IX. The Follow-up Committee, responsible: (a) for continuity of what is discussed or transacted until definitely disposed of, hence: (b) for having the reports available for consultation, and (c) profitable experiences codified for convention to follow.

X. Joint Committee on General Information: To provide a "when-in-doubt" center for every delegate, or anybody else, wishing to make inquiry. "Never Closed" should be its motto. Its equipment of reference books, folders, large local map, etc., to be a cumulative asset, for the benefit of future conventions. One of its special functions, to keep informed of changes in program; another, to be equipped with volunteers, if not paid workers, for preparing as quickly as possible attendance lists with classification according to name, location, occupation, etc.

XI-XIII. In General: XI. Mobilizing volunteers for special work (important when the attendance amounts into the thousands); a responsibility of the convention committee primarily, but to be shared by all.

XII. Democracy in Conventions: An essential to their lasting success. The convention committee to see that the whole spirit of the management is to make each delegate feel ample opportunity both to give and to get—to discuss, to exchange ideas, to meet kindred spirits, as well as to listen to session papers.

XIII. Research: The art of managing conventions is in decided need of advancement, and obviously the careful study of many different ones would be important for a committee in general charge; hence, attention to bibliography of convention management.

Suggestions for improving these tentative specifications may be sent to "Extension Service," care Boston Public Library, Boston 17, Mass.

Reciprocity in the Practice of Professional Engineering

The Council of State Boards of Engineering Examiners representing 16 states in conference Oct. 2 and 3 at the Congress Hotel, Chicago, agreed upon rules for the reciprocal registration of professional engineer. These rules provide that an engineer registered in one state may be permitted to practice in other states which are parties to the reciprocal registration agreement. The articles or agreement prepared by the conference will be sent to the various State Boards of Engineering Examiners and will become operative as rapidly as signed by the various boards.

A resolution was passed by the conference that each state board endeavor to have state laws changed where necessary so as to allow an engineer going into another state to practice under reciprocal registration without the payment of another fee.

Reciprocal registration with Canada and Mexico was provided for in the appointment of an investigating committee. At the present time engineers going into Canada cannot practice unless registered in Canada. Mexico has given notice that American engineers will not be allowed to practice in Mexico without equal recognition for their engineers.

The various states were represented at the conference as follows: Arizona, G. M. Butler; Colorado, R. J. Grant, R. G. Hosea; Florida, G. K. Armes, H. D. Mendenhall, C. H. Ruggles, C. S. Hammatt; Indiana, C. A. Walb; Illinois, T. L. Condron; Iowa, L. M. Martin; Louisiana, Marcel Garsaud; Michigan, J. J. Cox; Minnesota, F. W. McKellip; New Jersey, T. J. Wasser; North Carolina, P. H. Daggett; Oregon, O. Laurgaard; South Dakota, John Berg; South Carolina, T. Keith Legare; West Virginia, George E. Taylor; Wyoming, Frank C. Emerson.

C. S. Hammatt, president of the National Council, presided and R. G. Hosea was secretary. The following new officers were elected: J. J. Cox, president, chairman of the Michigan State Board of Engineering Examiners, Ann Arbor, Michigan; vice-president, O. Laurgaard, president, State Board of Engineering Examiners, 520 Corbett Bldg., Portland, Oregon; secretary, P. H. Daggett, State Board of Engineering Examiners of North Carolina, professor of electrical engineering, University of North Carolina, Chapel Hill, N. C. The next annual meeting will be held in Chicago.

The articles of agreement for the reciprocal registration of engineers follow:

Article 1. Reciprocal registration shall be granted only to an applicant who is already licensed in some state which is a member of this council. A detailed professional record, properly attested, and accompanied by references as to character and qualification from three registered practicing engineers shall be filed with the applicant's board of examiners. Qualification for reciprocal registration shall be determined upon the basis of such professional record, through consideration of which shall constitute examination.

Article 2. Engineering experience gained by the applicant prior to his reaching the age of 18 years shall not be counted as a part of his professional experience.

Article 3. Professional experience shall be considered as beginning when the candidate has entered upon a position in professional engineering work which requires original thought and responsibility. For example:

(a) In the field experience shall begin to count when the applicant reaches a position of responsibility equivalent to that of actual transitman.

(b) In the shop or laboratory experience shall begin to count only after apprenticeship, foremanship, inspectorship or other subordinate positions unless the work done specifically shows that the applicant possesses originality of design and has had responsibility in his subordinate positions.

(c) In the office or drafting room experience shall begin to count when the applicant ceases to do merely tracing, lettering or purely mechanical work requiring for its performance merely manual dexterity and enters a position of responsibility where he begins actual design.

(d) Experience in the teaching of engineering shall begin to count when the applicant is a full time instructor in engineering in an engineering school of recognized standing and each year of teaching shall be considered equivalent to one year of practice.

Article 4. The applicant shall have had 10 years of experience in professional engineering and in addition shall show that he is qualified to design as well as to direct engineering operations, as evidence of qualification for reciprocal registration and his experience record shall show progressive advancement in the character of the work performed.

Each case shall be considered on its merits, and the experience record must be given in such complete detail that the Board of Examiners can determine the character of work performed by the applicant.

Article 5. Graduation from an engineering school of recognized standing shall be accepted as the equivalent of four years of such practice.

An engineering school of recognized standing shall be one which requires the equivalent of a high school or preparatory school diploma as an entrance requirement and demands the equivalent of a four years' course in engineering for graduation.

Article 6. Making reciprocal registration operative between the states shall be done by means of certification from one state to another of the applicant's qualification. This certification shall be by means of a card or form bearing the date, serial number, and signatures of the officers and the seal of the board of the state issuing same. This card to be printed and distributed by the Council of State Boards of Engineering Examiners.

Article 7. Whenever an applicant applies to his own state board for reciprocal registration if his qualifications fully comply with the standard herein provided he shall be granted the same.

Article 8. The aforesaid reciprocal registration certificate shall be prima facie evidence of qualification for license in any state, member of this council, upon presentation thereof, together with the legal fee required and such information (other than evidence of qualification) as may be requested for the records of the board to whom the application is made, such board shall issue license or registration to the applicant.

Article 9. Any reciprocal certificate may be revoked by the state issuing same upon presentation to its Board of Examiners of good and sufficient evidence of incompetence or that the applicant's character warrants such revocation.

Article 10. Should any questions or disagreements arise, or should any points in the above agreement appear to require interpretation, such questions shall be referred to the Council for action at its next regular meeting; or in case more expeditious action shall be necessary, they may be acted upon by the council by letter ballot.

If the letter ballot, such ballot shall be conducted through the office of the secretary of the Council in the customary manner, and the votes shall be counted not later than sixty days after forwarding from his office, by registered mail, of the questions at issue. The Secretary of Council shall thereupon immediately certify to the various member boards the roll call and results of the vote, and the determination of the questions at issue, and consequent actions shall be in accordance with the majority of the votes recorded.

Central States Waterworks Convention.—The Annual Convention of the Central States Section of the American Waterworks Association will be held Nov. 2 and 3 at Pittsburgh.

Methods of Constructing a Deep Core-Wall

How the Steel Sheet Piling Was Driven, Excavation Handled and Concrete Placed for Wanaque Dam Described in Paper Presented Sept. 13 at Annual Convention of New England Waterworks Association.

By ARTHUR H. PRATT,
Chief Engineer, North Jersey District Water Supply Commission, Newark, N. J.

The Wanaque Dam under construction by the North Jersey District Water Supply Commission will impound the waters of the Wanaque River, one of the tributaries of the Passaic River, at a point about 25 miles north of the city of Newark. The Wanaque Reservoir, which will supplement the present Pequannock River supply for Newark and will also serve other neighboring municipalities, will impound between 11,000 and 27,000 million gallons, giving a safe yield of 50 to 100 m.g.d., depending upon the needs of the municipalities which decide to enter the project. The reservoir will be about 6 miles long and 1 mile wide.

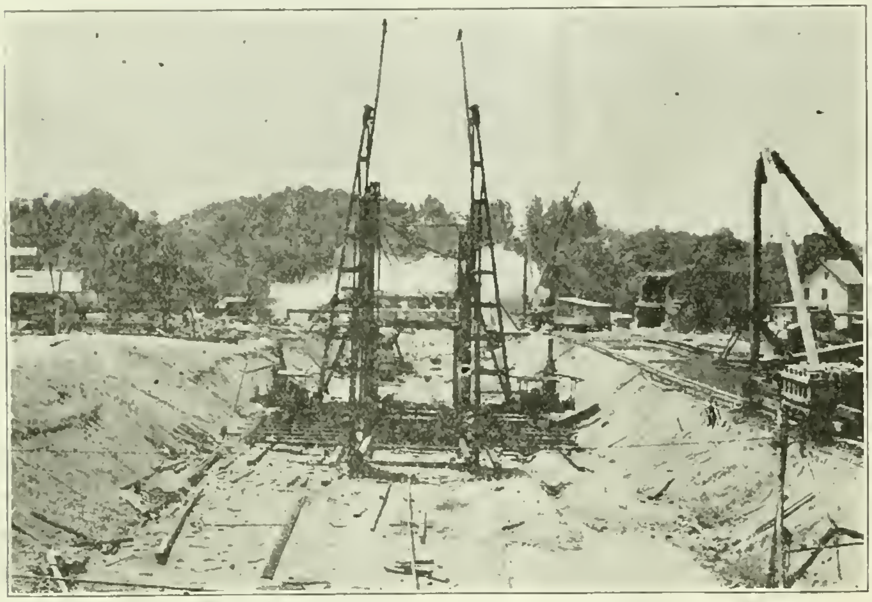


Fig. 1.—Sheet Piling Rigs and Guide Frame.

General Methods for Constructing Core-Wall.—The site of the dam is across a valley about 1,500 ft. wide which is to be closed by means of an earth dam having a concrete core-wall extending to bedrock which outcrops on both hillsides but at the bottom of the valley dips to about 100 ft. below the surface. The rock is gneiss and the overburden is water-bearing sand and gravel. The present channel of the river crosses the site of the dam near the south end and the river bed and is partly on the ledge rock which gradually dips away from the river to the deepest place near the middle of the valley. The method adopted for constructing the core-wall was to drive two walls of steel sheet piling across the valley, excavate between them meanwhile bracing the steel sheeting with timber and then fill the trench with concrete. The type of sheeting used was the Lackawanna, arch-web, 35-lb. section. Previous to putting down the sheeted trench, a stretch of open cut, with sloped sides, was taken out with a steam shovel, giving a level path upon which to erect the frame for guiding the piling and for working the two pile-driving rigs, one on each side of the trench. These rigs had an A-frame 75 ft. high, with an extension to a total height of 92 ft., giving a clearance sufficient to handle and mesh one 50-ft. pile into another when the latter has been driven about 10 ft. Rigs were equipped with Vulcan No. 10 steam hammers and mounted on skids sliding on sills laid normal to the trench.

Sheeting Put Down as a Wall.—In driving the piling the method used was to put the sheeting down as a wall and not as a series of individual piles. First a portable guide frame 48 ft. long made of 12x12-in. timbers was set up over the deepest part of the trench. This frame was constructed so that it could be adjusted to various widths. The aim being to obtain a trench 20 ft. wide at the bottom, and there being no experience upon which to determine the probable deviation of sheeting for such deep driving, the guide frame was first set to a width of 22 ft. After the piling was driven, the average top width was found to be actually 21.5 ft. The deviation from the vertical at the rock was found to be about 6 in. for each wall of piling, sometimes wider and sometimes narrower than the width at the top. On top of the rock the slope of the ledge surface forced the piling out of line so that the narrowest trench was 18.6 ft. and the widest was 24.4 ft. Later on with this experience to govern and for the shallower trench the width was reduced to 14 ft.

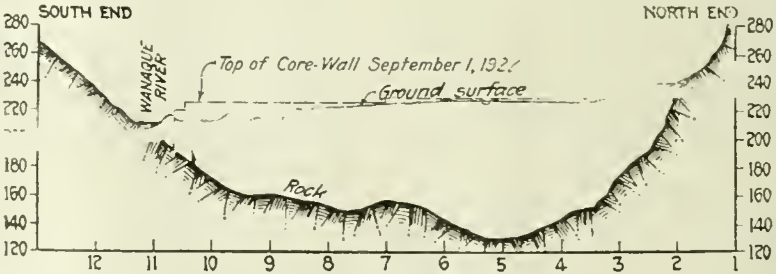


Fig. 2.—Profile of Core-Wall.

Sequence of Pile Driving Operations.—A wall of 50-ft. steel piling was set up on each side of the guide-frame and driven into the ground a few feet so as to hold the toe in place. Extreme care was exercised for the first set to have the piling true and plumb. This precaution was found to be very important as the first piles driven serve as pilots for all succeeding piles. Succeeding frames were also set up very carefully. After the first stretch of piling was erected, driving was begun on a set of three piles at the middle of the frame. When the first three piles were driven a few feet the adjacent three on each side were driven and so on, the rule being, in general, to drive no pile more than 4 ft. in advance of its neighbor. This method was continued until the top of the middle pile of the set was down to the surface of the ground, the bottoms of the adjoining piles then being in staggered diagonal lines to the surface of the ground. The frame was then moved ahead, another frame-full of piling set up adjoining the first and driving resumed until the new set and adjoining members of the first set were down to the surface of the ground, the end piles being always left stepped-up in approximately 4-ft. steps.

As required, additional lengths of piling were spliced on top of the lower set by means of a 7-in. channel and a ⅜-in. x 6½-in. plate, bolt-holes to fit being previously punched in the ends of the piles. In this manner, by gradually working the wall down with its bottom to a slanting line, one of the steel members finally intersected the line of rising rock as shown more clearly in Fig. 4. While the first frame was set up over the deepest point, the first pile to strike rock was some 50-ft. to the south. Driving to rock continued then until the rock outcrop at the north end of the dam was reached.

Determining Length of Piles by Sounding.—The lengths of piles to be driven were at first determined by scale from the rock profile developed by the original borings, but on account of the great uneveness of the rock it was later found to be better to make careful soundings, with the pile-driving rig and a steel rail, on the line of piling to determine the appropriate lengths of piles more accurately in advance. After the sheeting had been extended to the north

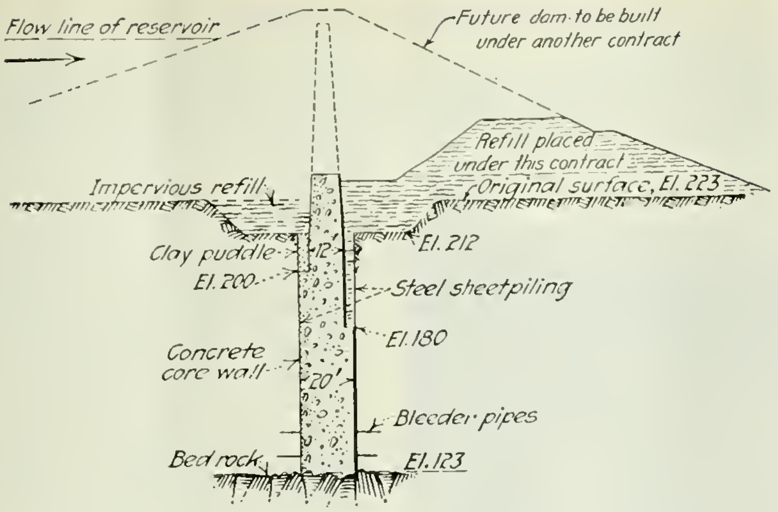


Fig. 3.—Cross Section of Core-Wall.

end, the pile-driving rigs were moved to the other end of the walls of piling, the frame was set up and the same methods used to extend the sheeting to the south end of the dam. When possible sets of three piles were driven at one time but when the penetration became difficult two piles were driven and finally for the deepest part only one pile was driven at a time. The maximum length of penetration was 84 ft. and the slowest driving in that vicinity was some 90 blows to the inch. The vertical position of the piling as established by the first set driven was maintained throughout the job so that no special wedge-shaped pieces were required.

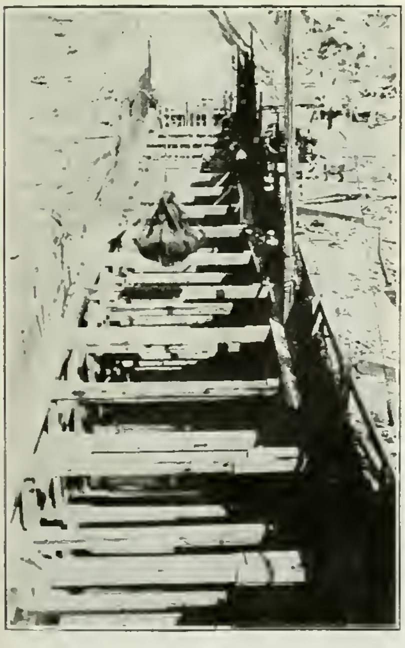


Fig. 5.—Timbering of Deep Core-Wall Trench.

A typical gang consisted of 1 foreman, 1 pile-driver operator and 6 pile-driver men for each rig. Two rigs were run under one general foreman and high pressure steam was supplied from a central plant so that a fireman was not usually employed with the driving rig.

Method of Handling Excavation.—As soon as the driving was completed at the north end excavation was begun with clamshell buckets operated from stiff-leg derricks running on a track on top of the west bank. As fast as the trench was excavated the sheeting was supported with 12x12-in. braces in bays 10 ft. on centers with the wales and braces spaced 6 ft. apart vertically for the upper 32 ft. of the trench. Below this the spacing was reduced to 3 ft. vertically and subsequently altered to double sets 6 ft. apart. Rangers 14x14-in. and 12x14-in. braces were used for the lower portion of the trench. Pumping was required immediately after the installation of the top set of bracing. Two 8-in. discharge, Morris Machine Co., 60-in. diameter, centrifugal dredge pumps were installed and dredged a considerable yardage of sand and gravel out of the trench, depositing it on the downstream dam embankment, besides pumping water. In addition the following pumping equipment was used: Four No. 9 Pulsometers; two 5-in. Emersons; two Lawrence 5-in. electric centrifugals and one Worthington electric 100-hp. 6-in. discharge, centrifugal. Rates of 5,000 and 6,000 g.p.m. were pumped in February, 1922, when the longest stretch of deep trench was open. The total pumpage was about 93,000 million foot-gallons.

Due to the porosity of the material and the low rainfall, the ground water level was very considerably lowered during the fall and winter of 1921-22. In general it remained about 20 ft. above water level in the trench. The result of this was to appreciably reduce the pressure on the timber bracing. After a few timber sets had been put in and the trench excavated about 40 ft. deep the bracing began to show strain; one wale cracked longitudinally in about the middle, some of the bracing cut into the wales as much as ½ in. and some of the braces split at the ends. A closer vertical spacing was considered, but the only change actually made was to substitute oak for pine bearing plates at the ends of the braces and to frame the timber with even greater care than before so as to be sure of a bearing over the entire 144 sq. in. section.

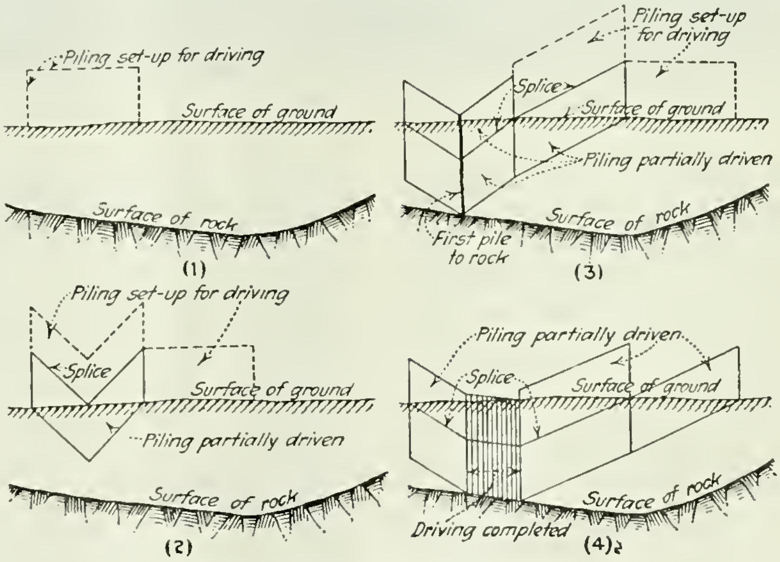


Fig. 4.—Sequence of Pile Driving Operations.

As the trench was deepened the ground water dropped and the pressures apparently never again reached those which obtained in the more shallow trench. Most of the braces when removed were sawed and cut out with no great difficulty and some were pulled out with a cable from a derrick hoisting engine without any cutting. In general the contact of the steel piling with the rock surface was found to be most satisfactory, but in a very few places the piling had encountered rock fragments near the bottom and had been twisted out of its interlock. There were a few piles that had been overdriven and "fishhooked." A small pile hammer was rigged on a derrick set upon the berm of the sloped excavation and any piles not showing a tight contact were redriven as was found necessary.

Turned up piles were burned off. For a stretch of about 20 ft. on one side in the bottom of the deepest section of the trench an additional set of short piling was driven inside of the original set. This was the only place where a double set was required.

Method of Concreting Core-Wall.—As soon as the earth was excavated from the northerly end of the trench, the concreting of the corewall was begun. Aggregate was obtained from a gravel bank on the opposite side of the river located on a terrace about 35 ft. above river level about one-half mile away from the corewall. The material was excavated by means of a steam shovel, hauled to and run through a crusher and a revolving screen. The portion of the output of the screening plant which could be used at once was hauled directly to the concrete mixer and the remainder stored in the excavated part of the pit for future use. There was about 50 per cent of excess sand in the pit which had to be wasted.

The concrete mixing plant located 300 ft. from the core-wall trench consisted of aggregate storage piles feeding into bins by a derrick and two Ranseme, size 63 mixers. Mixed concrete, mostly proportioned 1:2½:5, was deposited in bottom-dump buckets hauled to the corewall trench on narrow-gage flat cars and transferred by stiff-leg derricks to the concrete forms. In the bottom of the trench, on account of the interference of timbering, concrete was placed through hoppers feeding into a vertical 10-in. steel pipe.

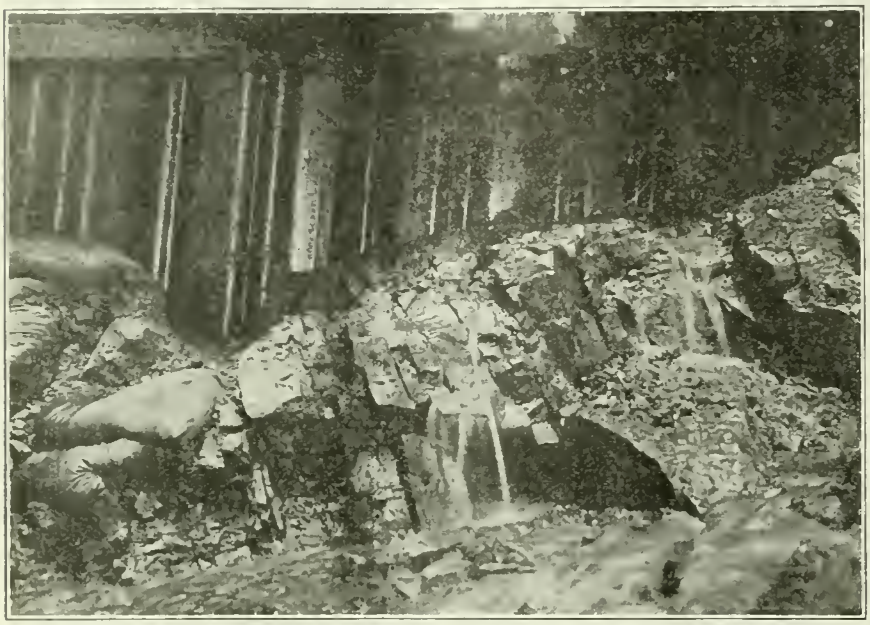


Fig. 6.—Bottom of Deep Core-Wall Trench, Showing Good Contact Between Sheet Piling and Rock.

In the first part of the work the water in the bottom was handled with no difficulty by means of blind drains or pipes on the sides of the trench next to the sheeting, but as the deeper portion of the trench was reached the quantity of water increased and begun to interfere with placing the concrete. The ground water back of the sheeting began to leak through and flow onto the concrete up to a level some 20 ft. above the bottom of the trench.

To obviate this trouble holes were burned in the sheeting near the bottom and 2-in. pointed and perforated pipes, 3 to 4 ft. long, were driven into the earth back of the sheeting. These drained the water away from the back of the piling so that the flow into the trench was largely confined to these bleeder pipes and was easily controlled. The bleeders were also useful in holding the ground water level down so that there was no difficulty in placing the subsequent layers of concrete. For the concrete in the deepest section additional precautions were used. The concrete was placed in short stretches—10 or 20 ft. long—and first a concrete bulkhead about 6 in. wide and 2 ft. high was built on either side about 2 ft. from the sheeting. Back of this wall a blind drain or pipe—sometimes connected with the bleeder pipes—carried the water ahead. Between these bulkheads concrete could be placed in the dry and afterwards the space back of the bulkheads was concreted —blind drains and drain pipes being cut off periodically.

Concreting was carried on from the north end of the trench towards the middle until the deepest point in the excavation was reached, Sta. 5+00, where the principal pumping plant was located. Operations were then undertaken part way across the valley near Sta. 7+50 at a point where there was a natural sump in the rock. Here another pump was installed and operations by the same methods as used before continued in the opposite direction until the gap between the new pump and the main pumping plant was filled. Then the closure at the deep place was undertaken, the space between the finished sections of core-wall being about 40 ft. Parapet walls 6 in. wide were built longitudinally across this stretch about 2 ft. inside of the sheeting and the water which came underneath the piling or through bleeder pipes was concentrated on either side between the parapet and the steel piling, leaving the center clear and dry to be filled with concrete.

When the center wall had been carried up about 6 ft., the spaces between the parapets and the steel piling were filled with rock fragments and the top was sealed over with concrete from one wall of steel piling to the other, leaving vertical steel pipes built into the concrete for pump suctions and float wells. The pumps were then arranged in three sets, one having its suction on the upstream side, the second on the downstream side and the third was arranged so that it could be switched to either side when one set of pumps of the three was being raised. By this means, alternately raising one pump at a time and concreting under it and building the suction pipes up, the closure in the deep section was accomplished. Meanwhile concreting proceeded at the river end of the trench where the rock is not so deep and was completed in that stretch before the final closure was made.

To insure that the concrete in the closure section might never be flooded the pump sections were built up clear to the top of the sheeted trench and pumping continued until the last batch of concrete below ground water level was placed.

MONTHLY PROGRESS OF CONCRETE IN CORE-WALL.

	Cu. Yds.
September, 1921	94
October	932
November	1,307
December	315
January	1,621
February	2,061
March	1,484
April	1,750
May	6,095
June	5,377
July	5,862
August	8,502
Total	35,400

The refill of the sloped excavation on the upstream side with rolled impervious material and on the downstream side with sand and gravel placed by the hydraulic method—both direct pumping and slushing from a dry fill—is in progress.

The construction of the core-wall was under the direct supervision of N. C. Holdredge, Assistant Chief Engineer. The contractor was W. H. Gahagan, Inc., and subcontractor for driving the piling was J. Roy Horton.

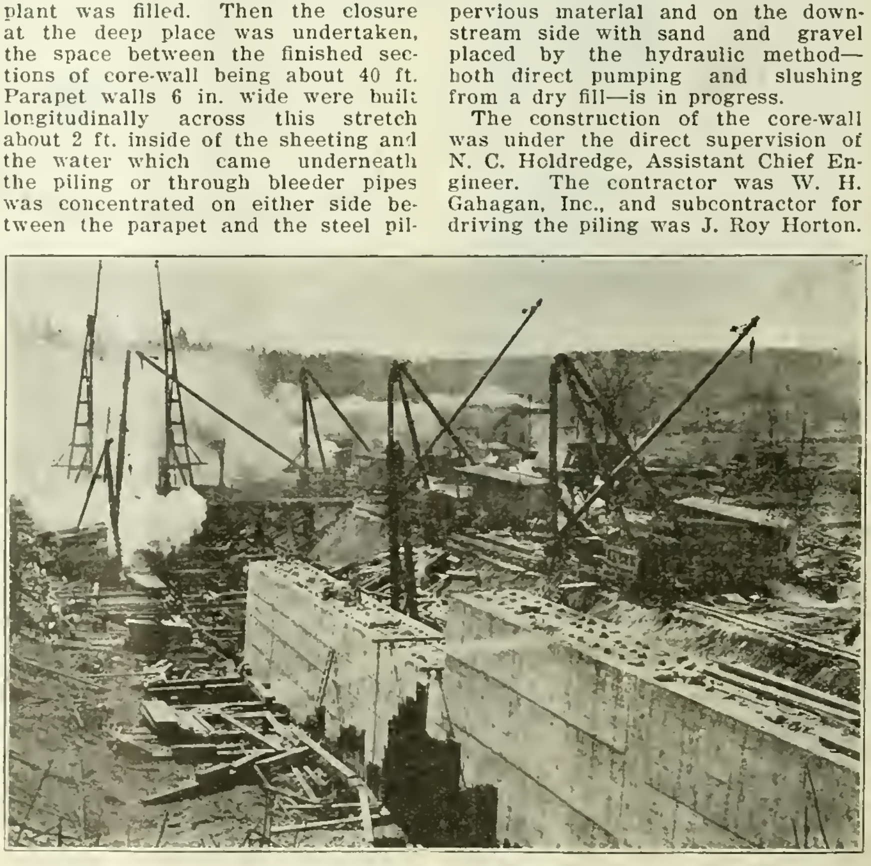


Fig. 7.—Construction View Showing Portion of Core-Wall Completed to Elev. 240; Lower Portion to Elev. 230.

A New Method for Purification of Water

Results of Loading Slow Sand Filter With Coagulants and Increased Rates of Operation Given in Paper Presented Sept. 14 at Annual Meeting of New England Waterworks Association.

By H. W. CLARK,
Chief Chemist, Massachusetts Department of Public Health.

A process of water treatment that will produce a sparkling water of low color without materially increasing its corrosive properties, has been much desired and such a method I believe we have worked out at the Lawrence Experiment Station of the Massachusetts Department of Public Health. I am calling this a new method, although we have been experimenting with it since the latter part of 1916 and have published in our reports short summaries of the results obtained.

What the Process Consists Of.—Briefly, the process consists of loading the sand of a slow sand filter with the ordinary coagulants used in mechanical filtration and operating such a filter generally at slightly more than the usual sand filter rates or about 5,000,000 or 6,000,000 gal. per acre daily. Filters loaded in this way remove a very large percetnge of the organic matter, especially the coloring matter of the applied water, produce an effluent clear, sparkling and altogether attractive, containing no more carbonic acid than in the raw water applied to the filters, and with the carbonic constituents of the water slightly increased.

Advantages of the Method.—This method of water treatment has many advantages over each of the other methods and but one drawback. The advantages are as follows: (1) The corrosive properties of the effluent are not increased, or if so, not materially, and neither aluminum sulphate nor alumina is found in the filter effluent; (2) the aluminum hydroxide with which the filter is first loaded is regenerated whenever its color removal properties begin to fail and hence is used over and over again—that is, the primary cost of coagulants is practically the final cost; (3) when receiving comparatively highly colored water from storage reservoirs practically free from mineral matter in suspension, such as silt, etc., the method of filter regeneration or removal of stored color which we employ, removes practically all organic matter from the surface of the filter as well as from its deeper portions and hence the necessity for scraping the filter is largely obviated—that is, the expense of sand removal and sand washing is reduced to a minimum. Filters of this type now in operation at the Experiment Station have been scraped only once or twice during a period of five years' operation at rates of 5,000,000 gal. per acre daily; (4) there is practically no consumption of alum. Filters operated now for five years have theoretically used up to date, taking into consideration the amount of aluminum sulphate primarily placed in the filter and the volume of water filtered, about .2 of a grain of sulphate per gallon of water filtered or practically one-twelfth of the amount necessary per gallon in successful mechanical filtration of the Merrimack River water such as applied to these loaded filters. As the loaded filter increases in age and the volume of water filtered and decolorized increases, the theoretical or apparent use of alum grows less and less per gallon. Successful mechanical filtration of Merrimack River water costs in the neighborhood of $6 or $7 per million gallons for aluminum sulphate while with this new method the cost to date has been about 55 ct. per million gallons for this sulphate, and this cost is constantly growing less; that is to say, in the next five years if we filter as large a volume of water as in the past five and without additional loading of the filter, the cost will be about 28 ct. per million gallons.

Results of Loading Filters with Aluminum Sulphate.—Up to date we have operated 11 filters loaded with aluminum sulphate, but for purposes of this paper the results of only five or six need be given. One filter, put into operation in January, 1917, and constructed of 4½ ft. in depth of sand with an effective size of .25 millimeter, was loaded with 80 tons of aluminum sulphate per acre of filter surface. The aluminum hydroxide was precipitated in the sand by flooding the filter alternately with small doses of solutions of soda ash and sulphate, although the filter can be loaded by mixing an alkali such as magnesium carbonate with the dry sand and then applying solutions of the sulphate. During its five years of operation the average color of the effluent from this filter has been 14 and the color of the water applied to it, 41—a removal of 66 per cent. During long periods the color of the effluent has averaged 7, however, and during portions of these periods the applied water has had a color of 60, 70 and even 75: that is, the filter has given an average color removal during such periods of about 90 per cent. In other words, the color line of the effluent has always been nearly straight while the color of the applied water has had many high peaks and the higher the color of the applied water the greater the percentage of the coloring matter removed.

Up to date this filter has removed rather more than 50 per cent of the organic matter determined as albuminoid ammonia and 60 per cent of that determined as oxygen consumed. It has been treated with weak solutions of caustic soda 24 times in five years in order to remove the coloring matter held in the filter by the aluminum hydroxide. After this treatment with caustic such a filter is washed with a volume of water equal to about 2.5 to 3 per cent of that filtered between treatments and is then ready for service for a period of two or more months.

It is not necessary to use filtered water for this washing out of caustic. The amount of caustic used up to date in the filter described has been .5 of a grain per gallon of water filtered, or, in other words, the expense for the caustic used has been about $2.50 per million gallons of filtrate. We believe, however, judging from later results, that we have used in this particular filter an excessive amount of caustic and that this figure may be much reduced.

A filter loaded with 150 tons of aluminum sulphate per acre has given an average color removal of 78 per cent during the past two years when operated at a 5,000,000-gal. rate and a filter constructed of sand as fine as .11 millimeter effective size and operated at a 2,500,000-gallon rate, has produced an absolutely colorless effluent since first put into operation. The cost of efficiently loading an acre filter is a small percentage of the cost of filter construction.

The bacterial results from this method are poor as the caustic used removes from the sand grains much of the gelatinous organic matter so necessary for the retention of bacteria but the effluent—clear, colorless and sparkling—is easily rendered practically sterile by the use of small amounts of chlorine, and chlorine is in almost universal use at filter plants at the present time in order that their effluents may be absolutely safe.

This method of treatment is particularly applicable to stored waters of a high color, the improvement of which physically is of more moment than the reduction of bacteria and it has seemed to us that there is no serious objection to it which would prevent its use upon a large scale. Recent experience has shown that perhaps the better way of loading the sand would be to carry on this loading process in comparatively small tanks or bins, and then transport the sand to the filter. By this method more even distribution of the hydroxide would be obtained and stratification prevented.

Table I illustrates some of the results obtained at the Experiment Station during the past five years:

TABLE I.—RESULTS OBTAINED AT LAWRENCE EXPERIMENT STATION.

	Filter Number					
	494	512	513	514	515	516
Tons of aluminum sulphate per acre precipitated in filter	80	75	75	150	150	225
Color removal (per cent)	66	73	73	73	78	76
Number of days between caustic treatments	65	67	67	89	89	90
Grains of caustic soda used per gallon of water filtered	.52	.21	.42	.16	.32	.16
Approximate percentage of wash water	2.5	3.7	3.7	2.8	2.8	5.5

Rate of each filter 5,000,000 gal. per acre daily.

Shanghai to Have New Sewer System.—The International Settlement of Shanghai, which with a population of about 750,000 is a component part of the general city of Shanghai with a population upwards of two millions, is to have its first sewer system in operation some time in November, according to estimates made in midsummer. The general sewer project that has been planned contemplates the building of a system that will serve the entire International Settlement and it is the construction of the first unit of this system that will be completed in November.

Use of Copper Sulphate in Reservoirs

Method of Application at Hartford, Conn., and Effects Upon Filter Runs Described in Paper Presented Sept. 15 at Annual Convention of New England Waterworks Association.

By J. E. GARRATT,
Office Engineer, Board of Water Commissioners, Hartford, Conn.

For several years copper sulphate has been applied to the various reservoirs of the Hartford water system at certain seasons of the year when the numbers of micro-organisms have become large. Previous to the filtration of the supply, which began late in the fall of 1921, the application of copper sulphate to the reservoirs was principally for the purpose of improving the taste and odor of the water. Since the introduction of filtration, the application of copper sulphate has continued for the purpose of lessening the amount of material which the filters have to remove from the water and thereby lengthening the filter runs and reducing costs of operation.

Method of Applying Copper Sulphate.—Copper sulphate is applied to the several relatively small old reservoirs of Hartford's supply by traveling over the reservoir surface in a small boat equipped with an outboard motor with a bag of copper sulphate crystals suspended over the side of the boat and in the water. A course around the reservoir starting close to the shore and gradually working out to the center is pursued. The course is determined wholly by experience and judgment. If the desired amount of copper sulphate has not been dissolved by the time the center of the reservoir is reached, such a random course is continued as will spread the remaining copper sulphate through the whole reservoir.

With the new large Nepaug Reservoir recently added to Hartford's supply, the application of copper sulphate is a much bigger proposition as it is a question of dissolving two tons or so each time. Here an 18-ft. motorboat is available. By experiment it was found that, with two bags of copper sulphate held in the water, one from either side of the boat near the stern, the boat would travel at the rate of about 6 miles per hour and 50 lb. of coarse granular copper sulphate per bag of 100 lb. from the two bags would dissolve in 5 minutes, using coarse mesh grain bags.

With this information as a basis it is possible to lay out courses over any portion of the reservoir which it is desired to treat so that the required amount of chemical can be dissolved in a more or less uniform manner. This ordinarily gives courses about 100 ft. apart. The dissolved sulphate is considerably dispersed by the churning of the propeller of the boat which is one of the decided advantages of a motorboat.

The Nepaug Reservoir is formed by damming two streams. There are, therefore, two more or less distinct basins to the reservoir. The outlet from the reservoir to the pipe line to the filter plant is located in one of these basins and an attempt is made to keep this portion of the reservoir low in micro-organisms.

How the Motor Boat Is Used.—This basin has a capacity of about 1,800 million gallons, is about 3,800 ft. long and has an average width of about 1,800 ft. It was first treated on June 17, 1921, when total micro-organisms at the surface numbered 1,300 (principally Asterionella 750 and Cyclotella 500) and at a depth of 30 ft. numbered 350 (Asterionella 200 and Cyclotella 100). It was decided to treat at the rate of 1.5 lb. per million gallons, which required 2,700 lb. of copper sulphate for the 1,800 million gallons in the basin. To dissolve these 2,700 lb. using two bags from the motorboat required 27 × 5 minutes or 2 hours and 15 minutes. During this time at a speed of 6 miles per hour the boat would travel about 13⅓ miles or about 72,000 ft. The average width of the basin being 1,800 ft. it is seen that 40 trips across would be required and since the length of the basin is about 4,000 ft. the courses would be 100 ft. apart.

These courses were laid out on a plan and land marks only were used as guides when the courses were traversed.

The motorboat carried 12 50-lb. bags of sulphate besides a crew of three men, one to guide the boat and two to dissolve the copper sulphate. Since the rate at which the sulphate dissolved was much more rapid when the 50-lb. bag was first immersed a more uniform rate of dissolution was obtained by putting a new full bag overboard on one side at the time that the bag already overboard on the other side was about one-half dissolved. No attempt was made by the men handling the copper sulphate to dissolve the last handful or two. When this stage was reached he passed the bag forward to the man steering the boat who dissolved the small remaining amount while the main operation continued. It took a little over three hours to apply the 2,700 lb., 2 hours and 15 minutes of which was actual time on the course and the remainder was time used in returning for other boat loads of sulphate.

Results of Treatment.—Water samples taken at two widely separated points on June 21, four days after treatment, showed that the total number of micro-organisms at the surface had been reduced to about 300 (Asterionella 150 and Cyclotella 130). Some few small fish were killed by the treatment. About six pailfuls were picked up along the shore.

At this same time several smaller coves and portions of the reservoir, so located as to be conspicuous from the highway, were treated with equally successful results. The previous year a green algae scum formed in certain of these coves. None occurred during 1921 after the copper sulphate was applied. The micro-organisms remained low in number throughout the remainder of the year.

Filtration Plant Operations.—The new filtration plant was started in a small way during November, 1921. Only part of the total supply was filtered. Permanent rate of flow and loss of head gages were not yet installed and a temporary sand washing outfit was available only. Piping is so arranged that water can be taken either from the Nepaug Reservoir, from the old West Hartford reservoirs or from both sources at the same time. The water to the filters was taken first from the big Nepaug Reservoir. The number of filter units in use were gradually increased until early in February, 1922, the whole supply to the city was being filtered. Nepaug water was used until the middle of March. During all of this time the micro-organisms which were very low in number totaled about 50 (maximum 80 and minimum 25). The average amount of water passed between scraping or rakings was about 125 million gallons per ½-acre bed.

From March 17th to April 3rd while high colored bottom water was wasted from the Nepaug Reservoir previous to the spring turn-over, water to the filters was taken from the West Hartford reservoirs. This raw water had a color of about 25. The numbers of micro-organisms were not as low as in the Nepaug water, but they were relatively low; 80 on March 17th and increasing to 185 by April 3rd. A filtered water with color of about 15 was obtained and the rate of clogging during this short period indicated that the quantity of water filtered between cleanings or rakings would have averaged about 100 million gallons per ½-acre bed had water of this character continued through the filters.

Nepaug water was again put onto the filter beginning April 3rd. By the end of the month micro-organisms had increased to 150 or so, more than one-half being Asterionella. In anticipation of the probable need of treating the Nepaug Reservoir with copper sulphate as was done the previous year, the principal West Hartford reservoirs in which the total micro-organisms had gradually increased to from 240 to 300 (in two Asterionella was the principal micro-organism and in another Nitzschaia) were treated with copper sulphate at the rate of 2.3 lb. per million gallons early in the month of May in order to have them available with water low in micro-organisms for use while the big reservoir was being treated.

Early in May with Nepaug water, filters clogged very rapidly. Runs of as little as 40 to 45 million gallons per ½-acre bed were the rule. It began to look as if night shifts would be needed on the washing outfit. On May 22nd Nepaug water was shut off so that the reservoir could be copper sulphated. While the total number of micro-organisms did not seem large yet there were several times as many as in the water which had been used previously. At the surface they totaled 300 and at the depth of 30 ft. 200. It was decided to treat the portion of the Nepaug Reservoir near the intake; that is, the same portion as was treated the previous year. Twenty-four hundred pounds of copper sulphate were applied on May 23rd in the same manner as during the previous year except that fine mesh burlap bags were used so that no fine grains of sulphate could escape. This was at the rate of about 1.3 lb. per million gallons of water treated as compared with 1.5 lb. per million gallons the previous year. The predominating micro-organisms were Uroglena 50 per cent and Asterionella 30 per cent. The treatment, however, was without material results. Total organisms at the surface were not reduced in number while at the depth of 30 ft. they increased very materially to about 600 total.

In the meantime the treated West Hartford Reservoir water with total micro-organisms of 50 to 100 was put onto the filters, filter runs lengthened appreciably to 65 or 75 million gallons between washings and the washing emergency was passed.

Effect of Increased Dosage.—But it was desired to use Nepaug water as soon as possible, so it was decided to treat the same portion of this reservoir again and at a rate of about 2.5 lb. per million gallons. On June 3, 1922, 4,000 lb. of copper sulphate, all of which was on hand at that time, were applied. This was at the rate of 2.3 lb. per million gallons. Total micro-organisms were 250 at the surface and 600 at a depth of 30 ft., half Asterionella and half Uroglena. Quite a few small fish were killed. Samples taken three days after treatment showed slight reduction in Asterionella and practically no reduction in the number of Uroglena. Samples taken the following day, June 8th, showed still further reduction in the micro-organisms at the surface (average total 140), but large increase in number at a depth of 30 ft. (average total 1,030).

On June 9 the change back to the Nepaug water was made, taking water from the intake nearest the surface where the micro-organisms were the lowest in number. On June 14 conditions were the same as on June 8, but by June 21 surface counts had decreased to an average of 65 and at the 30-ft. depth to an average of 100.

Micro-Organisms and Filter Runs. As a result of more or less off-hand consideration of all this it appeared that all that was necessary to do in order to keep filter runs long was to keep micro-organisms low in number. Careful watch, therefore, was kept of micro-organisms. No considerable increase was noticed in the Nepaug water, but all of a sudden early in July filter runs of 18, 20, 21, 23, 25 million gallons were gotten. Experience had shown that filters could be lightly raked over once or even twice without materially increasing the amount of sand to be scraped off and washed ultimately so that no washing crisis seemed at hand, but on several beds there were periods of only 10 days between rakings or scrapings and in one case only 7 days.

While water in the Nepaug reservoir was low in micro-organisms it was found that water in the West Hartford reservoirs into which the pipe line from Nepaug emptied, had developed a considerable growth of micro-organisms (Nitzschia), so on June 8 this reservoir (Reservoir No. 5, so-called) was shut off and the Nepaug water allowed to pass directly to the filters. Reservoir No. 5 normally is used like a surge tank to take care of the excess or to supply the deficit of Nepaug water over or under the amount passing through the filter at any time.

About July 11 Reservoir No. 5 was treated with 2.3 lb. per million gallons of copper sulphate, the micro-organisms reduced from 270 to about 100 by July 18 and on that day the gate on the line to and from the treated Reservoir No. 5 was opened again. At the time this treated water was again free to pass onto the filters one ½-acre bed had only passed 30 million gallons of water and had lost 3 of its 5 ft. of head. Other beds had either just started on new runs or were practically at the end of runs of 20 to 25 million gallons as stated above.

A few days later it was noticed that loss of head on the bed which was in the midst of a run, Bed 3, so-called, began to decrease. It contiuned to decrease. At the same time a slimy deposit on the walls and bottom of the aerator disappeared. Bed 3 gained a new lease of life and continued in service until Aug. 24, passing 90 million gallons of water. Runs on other filters since the last of July have varied from 45 to 80. Micro-organisms in Nepong reservoir have continued low, 30 to 50. But at the present time, Aug. 25, micro-organisms in Reservoir No. 5 have again increased to over 300 without as yet causing any noticeable increase in the rate of clogging of the filters.

Presumably we have not as yet gotten the whole story in regard to the amount of copper sulphate needed for effective treatment or in regard to the relation between number of micro-organisms and lengths of filter runs, but it is thought from the information so far collected that the application of copper sulphate has possibilities as an aid to economical filter operation with Hartford's water.

Method and Cost of Removing Moss from Irrigation Canals with Disk Harrow

During the past season a type of disk harrow which has been used with marked success on the South Side Twin Falls irrigation project in Idaho, was employed on the King Hill Project in the U. S. Reclamation Service for removing moss and weeds from canals and laterals. The following account of the work on the King Hill project is taken from an article by Mr. A. M. Rawn, engineer, in the August Reclamation Record.

Construction of the Harrow.

For the purpose of constructing the harrow the following parts were purchased: 8 disks, 20 in. diameter; 4 washers, bumper, 9½ in., No. KK—667; 2 spools, spacing (used with ⅞-in. square, 1/32-in. oversized shaft); 4 spools, bearing; 2 washers, K—1028; 2 top half boxings, KK—581; 2 bottom half boxings, KK—582; 2 top half boxings, KK—583; 2 bottom half boxings, KK—584; 4 sets wood boxings; 2 washers, 1-in. round, cut; 2 nuts, 1-in.; 12 ft. steel, medium, ⅞-in. square, 1/32-in. oversize; 17 ft. iron, strap, ¼ by 3; 20 ft. iron, strap, ⅜ by 2.

The 8 disks are assembled 4 each on a ⅞-in. axle, the assembly on each axle being as follows: 9½-in. bumper washer, 20-in. disk, bearing spool, 20-in. disk, spacing spool, 20-in. disk, bearing spool, 9½-in. bumper washer, 20-in. disk, washer K—1028, 1-in. cut washer, 1-in. nut, and cotter pin.

The completed harrow resembles the letter T with the cross bar bent into a flat inverted V, each leg of the V forming an angle of about 80° with the stem which represents the pole. The pole is heavily ironed with a ring in its outer end for attaching to draft cable. The pole center line projected would pass 6 inches above the two disk axles in the harrow in use on this project, but it is believed that the center line of the pole and axles should be in the same plane, so that the harrow will operate with equal effect when it is inverted in the canal, as frequently happens.

The pole is attached to the disk axles at two points on each axle for an 8-blade harrow, the boxings being located on the bearing spools in each set of disks. For a 16-blade harrow now under construction on this project it is the plan to attach the pole to each axle at three points for additional strength. For connecting the pole to the axles heavy strap irons are run from pole to boxings in the form of hounds, the straps to the outer ends of the axles being bolted to the pole rigidly, whereas those to the inner boxings are bolted to the pole with one bolt only, allowing the inner end of each set of disks to move up and down to conform to the ground surface. Weight and strength are of great importance; therefore heavy strap iron should be used throughout for pole irons and hounds.

The harrow is dragging through the canal by means of a cable run through the pole ring and thence to a team on each bank. Three men and two teams operate the harrow; two of the men act as teamsters, while the third guides the harrow by slowing down each team as necessary.

Cost of Removing Moss.

The cost of mossing four different sections on the main canal during the latter part of June and early part of July was as follows:

Section No. 1 consisted of 4,700 ft. of 22-ft. base canal, with depth of water about 4 ft., both banks of which were about equal height. The field cost for this stretch was $25.

Section No. 2 consisted of 1,400 ft. of main canal, 28 ft. bottom width and 4 ft. depth of water, the banks of which were about of equal height. In this section the moss extended throughout the entire length almost across the entire channel. This stretch was mossed at a cost of $12.50.

Section No. 3 consisted of 1,700 ft. of main canal, with the same cross section as section No. 1 except that the canal is on steep hillside and necessitated the use of 200 ft. of cable, divided 150 feet on one leg and 50 feet on the other. This stretch of canal cost $27.

Section No. 4 consisted of a stretch of canal 2 miles in length, the banks of fairly uniform height and of about the same cross section as section No. 1, with the moss growing for the most part close to the banks. This stretch of canal was mossed at a cost of $19.

A marked advantage of the harrow is that within the limits of ordinary canal flow, depth and velocity increase its efficiency by moving out the cut moss. It is useful also in that it cuts down silt bumps, and if kept sharp it is successful in removing weeds from along the berm. It does not become choked with weeds and moss and it is never necessary to drag it from the water for cleaning.

From the limited experience with the machine on this project it is Mr. Rawn's opinion that the 8-blade harrow will be most effective in laterals up to 10 ft. bottom width; for large canals one with about 16 blades will be most efficient.

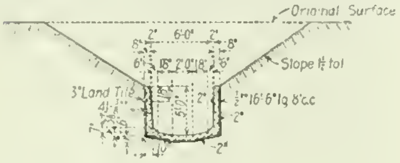
Cost Data for Intercepting Drain Fall River, Mass.

In order to protect the surface water supply of the city of Fall River, Mass., an intercepting drain was constructed in 1915 by the Watuppa Reservoir Commission. This drain was built of reinforced concrete and was about 14,000 ft. long. The total cost was $190,000. The standard sections are shown in this accompanying illustrations.

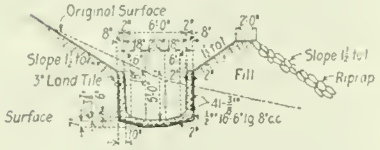
We are indebted to Mr. H. K. Barrows, consulting engineer of the commission for the following cost data on the 1915-1916 work on this drain:

COST PER LINEAR FT. FOR DIFFERENT SECTIONS OF DRAIN.

	Per Lin. Ft.
6 ft. open section (1,470 lin. ft.)—	
Concrete, 0.427 cu. yd. @ $9.50	$4.06
Reinf. steel, 40.64 lb. @ $0.023	0.95
Excavation, 2.7 cu. yd. @ $0.85	2.30
Total	$7.31
8 ft. open section (2,600 lin. ft.)—	
Concrete, 0.458 cu. yd. @ $9.50	$4.35
Reinf. steel, 55.31 lb. @ $0.023	1.29
Excavation, 4.1 cu. yd. @ $0.85	3.49
Total	$9.13
10 ft. open section (5,608 lin. ft.)—	
Concrete, 0.505 cu. yd. @ $9.50	$4.80
Reinf. steel, 59.50 lb. @ $0.023	1.39
Excavation, 5.4 cu. yd. @ $0.85	4.60
Total	$10.79
6 ft. covered section (154 lin. ft.)—	
Concrete, 0.536 cu. yd. @ $9.50	$5.10
Reint. steel, 72.46 lb. @ $0.023	1.70
Excavation, 1.5 cu. yd. @ $0.85	1.27
Total	$8.07
10 ft. covered section (2,312 lin. ft.)—	
Concrete, 1.00 cu. yd. @ $9.50	$9.50
Reinf. steel, 145.41 lb. @ $0.023	3.41
Excavation, 3.7 cu. yd. @ $0.85	3.14
Total	$16.05

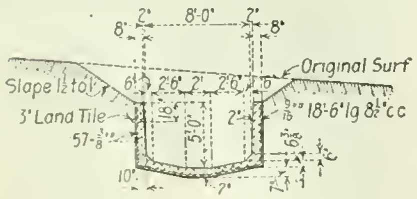


Standard for Open Cut 6ft. Section

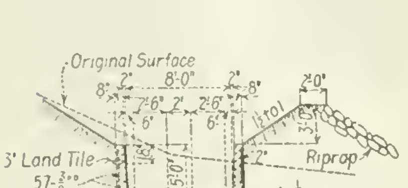


Standard for Cut and Fill 6ft Section

Standard Sections for 6 ft. Open Drain.



Standard for Open Cut 8ft Section



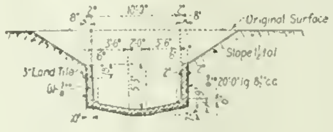
Standard for Cut and Fill 8ft Section

Standard Sections for 8 ft. Open Drain.

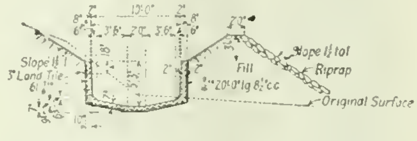
In the foregoing tabulation the costs as given are approximate actual costs, not contract prices. Unit costs are, however, for the work as a whole and are not available in segregated form for the various individual sections of drain. Rock excavation is not included.

The unit cost of concrete (7618 cu. yd.) was made up as follows:

	Per Cu. Yd.
Labor, teaming, insurance, etc.	$4.27
Machinery, power and general	0.93
Lumber for forms, etc.	0.25
Sand, $0.66, and stone, $1.39	2.05
Cement	2.00
Total	$9.50



Standard for Open Cut 10ft Section



Standard for Cut and Fill 10ft Section

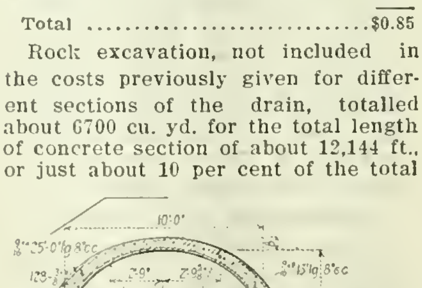
Standard Sections for 10 ft. Open Drain.

The cost of forms (in place and removed)—made of wood, for a total area of about 280,000 sq. ft. was about 8 ct. per sq. ft.

The unit cost of earth excavation (58,500 cu. yd.), including refill, was as follows:

	Per Cu. Yd.
Clearing and burning	$0.02
Stripping and storing loam	0.17
Excavating other earth	0.47
Backfill, etc.	0.16
Machinery, pumps and miscel.	0.03
Total	$0.85

Rock excavation, not included in the costs previously given for different sections of the drain, totalled about 6700 cu. yd. for the total length of concrete section of about 12,144 ft., or just about 10 per cent of the total excavation. Of this rock practically ⅓ was boulders of ½ cu. yd. or more, the remainder ledge.



Standard Covered Drain 10ft Section

Standard Sections for 10 ft. Covered Drain.

The cost of rock excavation was about $19,500, which averages $1.60 per linear foot of drain and about $2.90 per yd. cu.

The base costs for labor and material were:

Ordinary labor, per day of 9 hours	$1.80
Single teams and driver, per day of 9 hours	3.75
Double teams and driver, per day of 9 hours	5.50
Cement, per bbl.	1.20
Sand, per cu. yd.	1.50
Crushed stone, per cu. yd.	1.58
Dynamite, per lb.	0.20
Reinf. steel, per lb.	0.023

Locating Leaks in Water Pipes with the Geophone

The geophone, a listening instrument invented by the French during the war to detect sapping and mining operations, can be used to locate leaks in water pipes, according to a bulletin issued by the U. S. Bureau of Mines. The bulletin states that by means of the geophones it is possible to hear water circulating in the pipes of the ordinary city mains situated 10 to 15 feet below the surface. The following test to locate a leak carried out at one of the busy corners of the Pittsburgh business district is described in the bulletin. Fig. 1 illustrates this test. Water was found to be seeping through the joints of the paving blocks at the point k. This area was approximately 150 ft. from the intersection of two streets. When the geophones were placed upon the paving at this point the sound of running water could be heard, the water seeming to come from the north. Sandusky Street at this point has a slight grade sloping to the south. At the time the observations were made the water company had been watching the leak for about two weeks and could obtain no information indicating the locating of the trouble. All the information it had was that the water was seeping out through the paving at k and that all of the gate boxes on the south side of East Ohio St. were full of water. Sounds of running water were first heard at k, and were followed back to gate box C-1, where the sounds were very loud. It was thought at first that the leak was located at C-1. Upon moving toward the center of the intersection of the street, however, the sound of running water was supplemented by a hissing sound. This sound could be heard anywhere within a radius of 40 ft. and determinations of direction all showed that it came from the supposed location of a T where the 10-in. main running down Sandusky St. joined the 15-in. main on East Ohio St. The water company's map showed that the T was located at the exact center of the intersection of the streets. The geophones showed so conclusively that the leak was in the T that accurate observations were not made to locate

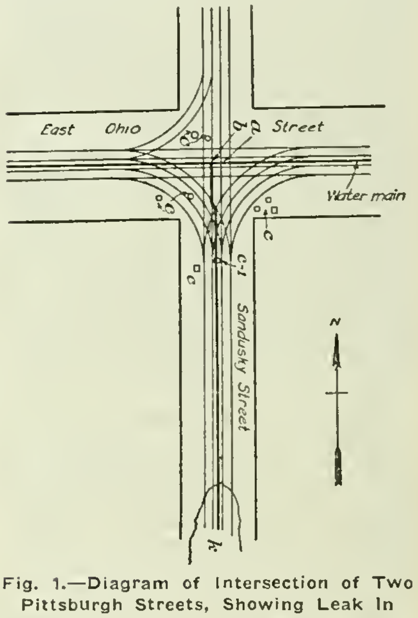


Fig. 1.—Diagram of Intersection of Two Pittsburgh Streets, Showing Leak In Water Main Located by Geophone.

the sounds with respect to the center line of the street. Digging showed that the T was 3 feet west of the point shown on the company's map. The water was issuing from one of the joints of this T. The leak had been located by means of the geophones with enough accuracy that only one hole was put down from the surface. The slight error was due to failure to check the map by careful determinations of direction.

In a second test the results were not so satisfactory. An account of these observations is given to show the care necessary to prevent the observer from being misled. There was a leak in a 1-in. pipe leading from a street main to a residence. The sound from the leak was transmitted along the pipe to the house and could be heard by placing the ear to the pipe in the cellar of the house. The pipe was buried about 10 ft. below the surface. Observations made upon the cellar floor pointed to the fact that the leak was probably close to the cellar wall near the point at which the pipe entered the cellar. Similar results were obtained from the surface. The sounds coming from the leak were distinctly audible close to the cellar wall, and as they were not heard elsewhere in the yard there was little doubt that the leak was at this point. As the continuous passing of heavy trucks interfered with the work, however, observations were made later during the evening quiet. This time the sounds from the leak could be heard faintly on the surface at points from 15 to 20 ft. from the house. The leak was later found to be here. The geophone operators were at first misled by the sound of the leak traveling along the pipe until the pipe came in contact with the solid masonry of the house foundation, when the sound was transmitted through the masonry.

The Service Charge

A plain matter of fact statement regarding the service charge—what it really is and its application is given in a circular issued by A. E. Walden, Operating Agent of the Annex Water Companies of Baltimore, Md. This circular, by the way, is one of a series of little pamphlets published by the companies for the education of its customers. We reprint the circular below.

The service charge or "readiness to serve charge" as it more properly should be called, is that portion of the expense known as "fixed charges," or money for interest, sinking fund, depreciation, material, labor, etc., to provide capacity to supply a demand for individuals, manufacturers or fire, entering into a completed water system, that must be borne by the citizens who are really to all intents and purposes stockholders. These charges begin even before any water is in the mains or the pumps started. The system may be completed and the mains laid to a prospective consumer's premises, as yet without water in them. The consumer (in this case the citizen-stockholder) in some way must pay his proportion of the above mentioned fixed charges, sometimes known as "static charges," on these mains and other appurtenant equipment in the form of pumps, dams, mains, filter plants, etc., before and after the water is flowing through them.

CONSUMPTION CHARGE — As soon as a consumer begins to take and use water he must pay an additional charge known as a "consumption charge," which varies with the number of cubic feet or gallons consumed in any period of time. This consumption varies as between different consumers. The money from this source goes to pay for coal, labor, chemicals, repairs, etc.

With the view of dividing all the fixed charges without discrimination between individual consumers, it is necessary to provide some method of apportioning them. It is done in this serve charge, plus $10.00 for the first 4,000 cu. ft. of water at 25 cts. per 100 cu. ft., making a total bill of $12.00.

This shows clearly that "A" and "B" each pays for just exactly what he gets.

We will say, there is another consumer "C," who usually requires more water than either "A" or "B," and that the ½ in. meter will not pass the necessary quantity to supply his demand. Now, "C" requires not only a larger meter but he requires the use of a larger portion of the mains and the pumping and other appurtenant equipment in the system for his use. Therefore, his readiness to serve charge should be higher, to be fair to "A" and "B." The demand reiness any time he wishes to use water.

It may be assumed, for the purpose of an illustration, that there are two consumers, "A" and "B," each having a ½ in. meter, each paying the same readiness to serve charge.

"A" has use for only a normal quantity of water and is economical in its used. We will say that in this case 1,000 cu. ft. of water in one quarter, or three months, is required, at 25 cts. per 100 cu. ft., with a readiness to serve charge of $2.00 per quarter. "A" would, therefore, have a bill first of $2.00 for the readiness to serve charge plus $2.50 for 1,000 cu. ft. of water at 25 cts. per 100 cu. ft., making a total bill of $4.50 for that quarter.

"B" who has the same size meter and service charge, uses more water and is not so economical or wastes it, has consumed in the same quarter 4,000 cu. ft. of water. "B's" bill will be, first $2.00 for the readiness to manner: First, the fixed or static charges are ascertained. Second, the meters of all sizes over ½ inch are reduced to an equivalent number of ½ in. meters. Third, divide the static or fixed charges by an equivalent number of ½ in. meters. This gives the service charge or "readiness to serve charge" as used here. In this connection it may be interesting to note that a ½ in. meter has sufficient capacity to supply the demand for most homes and is placed on services of 70 to 80 per cent of all consumers. On the readiness to serve charge or service charge every consumer pays exactly the same amount of money for the same capacity demand. A ½ in. meter is nothing more or less than an indication of the demand which the consumer desires to have in readquired by "C" indicates that it is necessary to place a ¾ in. meter to give him satisfactory service and, as a ¾ in. meter has a capacity one and three-quarters times as great as a ½ in. meter, this fixes "C's" service charge at 1¾ times $2.00 or $3.50 per quarter and, as will be seen, has no other significance, and is in no way rental for a meter.

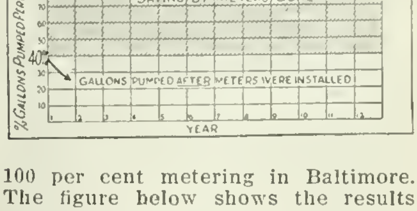
Now, "C" uses in the same quarter 10,000 cu. ft. of water which at 25 cts. per 100 cu. ft. would be $25.00 plus the service charge of $3.50 making a total bill of $28.50.

"C" has paid exactly the same, for the same service rendered, as has "A" and "B," his bill being larger to the extent of the increased demand and the increased quantity of water supplied. There is no other way in which it is possible to allow each consumer to use just the quantity of water he desires and render fair service between an individual consumer and any other consumers; or in other words, a fair and just bill as compared with that of his neighbor. In any other way he either pays for what his neighbor gets or his neighbor pays for what he gets. This is strictly true where the habit of people in different types of homes and with a number of different fixtures, is taken into consideration.

In a municipal system such as is here given consideration every taxpayer and consumer is a stockholder in one of the largest and oldest forms of public utility. He should be interested in seeing that such a system is self-sustaining, so that it will not be necessary to make any charge in the form of taxes or provide money other than for extensions to care for the growth of the system. The method of charging for water here illustrated will make the water works self-sustaining. It will ultimately save the citizens of Baltimore millions of dollars, because the greater part of the water supplied for domestic consumption must be again handled at the sewage disposal plant.

By reducing waste and consuming only sufficient water for the health and cleanliness of the community (about 30 to 50 gal. per capita daily) a given investment on such a metered system will usually care for four times the number of consumers served on a flat rate system. This would enable a given system to supply water for four times the number of years, consideration being given the growth of the community, as compared with a system where any flat rate method of making a charge for such service is in effect. If Baltimore were entirely metered on the basis outlined, it would result in a reduction in the present tax rate of 15 to 20 ct. without any additional cost and with a possibility of a lower cost to its citizens.

The metered system with the service charge will ultimately reduce the cost of water supplied to you and your fellow citizens. Therefore, you should be interested in bringing about



100 per cent metering in Baltimore. The figure below shows the results of metering the system at Atlanta, Ga.

A reduction of 60 per cent in the total pumpage. (Only one instance in many) reductions like the above reduce the insurance and the tax rate. The answer is—Meters. Mr. Citizen-Stockholder, are you interested?

The Collection and Disposal of Refuse

Modern Methods Are Some of the Problems Experienced in Their Use Outlined in Paper Presented Oct. 6 at Annual Meeting of American Society for Municipal Improvements

BY SAMUEL A. GREELEY.

Of Pearse, Greeley & Hansen, Consulting Engineers, 39 W. Adams St., Chicago.

If service to householders and proprietors be held of first importance, with economy of operation following closely, then the observer's perspective shows the disposal of refuge as of somewhat less importance than the collection service. If two somewhat similar cities (as for instance St. Paul and Minneapolis) have equally good collection service, it is quite possible that general satisfaction among householders can be secured with different methods of disposal. If the different disposal methods are well administered, the difference between them is largely one of annual cost.

Therefore, let me state the four parts or phases of the refuse problem as follows:

a. The house treatment.
b. The collection.
c. The transportation or haul.
d. The final disposal.

Of these phases of the problem, the collection and transportation are the costly part of the work (on an annual basis). As the collection also orients or establishes the standard of service to houses, it merits first consideration in the development of a general plan. If the development of general plans for refuse disposal, or the readjustment of existing methods, were oriented squarely to the relative importance of these various phases of the problem, the shifts and failures, which our informed observer finds, would not so frequently occur.

Let us note, however, that recent years have marked a promising realization of the importance of collection work and the related problem of haul. Much has been accomplished through motorization as at Los Angeles, Montclair, Minneapolis, and elsewhere, although final economics are not yet established. Further progress toward economy has resulted through the use of the tractor-trailer and the establishment of transfer stations which permit the decrease of the expensive collection haul with an increase in cheaper quantity haul.

Importance of Haul.—Thus a review of refuse disposal practice in the light of some of the projects recently developed, particularly in the larger cities, reveals, among other things, a growing realization of the importance of haul. By haul is meant the travel of the loaded collection unit from the collection district in which the refuse is produced to the place of disposal. This item in fact links up the various phases of the refuse disposal problem from the house treatment, to the final disposal. In plain terms the gradual exhaustion of dumping grounds and disposal sites and the increasing cost of haul, have curtailed the collection service to such an extent that public opinion has come to the front for improved service. This is a situation which, if rightly turned, can greatly assist the development of improved service through acquirement of sites, overhauling of collection equipment and construction of disposal works. With increasing costs of haul old appropriations cannot continue the collection service desired, so that betterments and economics are requisite. If nearby dumps become filled, how can the old budget carry double or triple the haul, without curtailing the service? This can only be accomplished by more economical methods, or by increased budgets, and often both are needed. Thus the haul becomes involved with the dump and the disposal plant, for oftentimes the method of disposal will increase or decrease the useful life of dumps.

Improved Operation of Dumps.—The dump, in my judgment, is likely to be a factor in the disposal of refuse in nearly all cities for many years to come. It should, therefore, be given much attention in operation and use. Of first importance is the sanitary maintenance. Efforts to secure a ratproof dump are becoming more prevalent, so that garbage is taken less frequently to dumps. The 1920 New York Commission reached the general conclusion that not only garbage, but rubbish and street sweepings as well, should be kept off of dumps. This consideration was an element in the decision which has led Philadelphia to take bids last month on a large rubbish and garbage incinerator.

As related to the problem of increasing hauls and the contingent stretching of the budget, the life of the dump becomes important. This is a local problem involving the availability and extent of dumping areas and of other methods of disposal. Thus if mixed refuse (garbage, ashes and rubbish) is burned, the bulk to be dumped is reduced by 60 per cent or more. If the garbage is fed to hogs, only about ⅓ need be otherwise disposed of. The matter of available dumping grounds has become accute in many of the larger cities including London and Chicago as commented on below.

A Typical Condition.—In a typical large American city the refuse problem required the ultimate disposal of the following materials:

Ashes.
Rubbish.
Garbage.
Manure.
Street Refuse.
Trade Refuse.

In the smaller cities, garbage and rubbish assume a larger relative importance. These refuse materials are disposed of in a number of ways of which the following are typical:

Most of the street refuse and ashes, with much rubbish, is taken to dumps. Measured by quantity, by far the larger portion of a typical city's refuse is dumped.

Manure (stable refuse) is mostly transferred to farms and truck gardens, but some of it frequently reaches the dumps.

There is nearly always some salvage, chiefly of rubbish. This is often done by scavaging dumps, but sometimes in specially built plants.

Hotel and restaurant garbage is generally fed to hogs, or rendered for grease and tankage. Relatively inert trade refuse is dumped. Thus the accessability of dumps (or loading stations) affects the cost of industrial output.

A variety of special methods of disposal have been developed for garbage, sometimes with the admixture of rubbish, ashes and other refuse materials.

Thus, for a typical condition, we find disposal by dumping used for as much of the refuse, as can be dumped without creating objectionable conditions; with special disposal works developed for the rest. There appears also to be in some cities a tendency to increase the proportion of refuse dumped either on land or at sea, sometimes resulting in the abandonment of the specially developed works. The location and accessibility of dumping grounds is, however, a direct factor in the cost of collection and haul; and dumps gradually become permanently exhausted from refuse disposal. Cities should, therefore, give careful consideration to their dump resources, with particular reference to the collection service and to other matters of disposal which decrease the amount of refuse to be dumped.

A Yard Stick for Haul.—The matter of haul may, therefore, have a determining influence on the development of special methods of disposal and the conservation of dumps, and it is therefore necessary to set up a measure for the relative value of haul. Local conditions will largely make up such a yard stick, but the effect on collection service and cost is one of the chief factors. Some data on the rate of collection work is given on Table 1. As an average figure for a typical large city, let us assume that a collection unit of two men can make collections of house refuse at the rate of 75 pick-ups per hour. If the unloading point is so located as to require four hours of haul, each such collection unit will serve around 300 houses per working day. If the team haul be reduced to three hours, the number of pick-ups (or houses served) will be increased to 375 per day. Under some local conditions the team haul requires as much as five hours time.

In larger cities, the team haul can be supplemented by quantity haul. If the team haul (averaged with collection service) costs $4.50 per ton, quantity haul may cost only a third time as much or about $1.50 per ton. What then is the economical relation between team haul and quantity haul. Obviously this can only be determined after a careful study of all the local conditions including the rate of collection work, the travel of teams and motors, the available locations for transfer stations, the life and location of dumps and disposal plants, rates of wages and other similar considerations. But the yard stick for haul is the number of houses to which collection service can be given by a unit of collection and haul equipment. With due regard to the life of disposal works and to sanitary conditions, the work of collection and haul should be planned to serve the maximum number of houses per day.

London Reports.—During the last 5 or 6 years, the refuse disposal of the Administrative County of London has called for special study largely through increasing costs of haul. From a population of almost four and one-half million, it is estimated that about 5,000 tons of refuse per day require disposal. The County is divided into 28 metropolitan boroughs and the City of London making 29 divisions in all. The following figures show the proportion in which the various methods of disposal are used:

Method of disposal—	No. of boroughs.	Percentage of refuse by weight.
Barges to dump	22	44.66
River to dump	13	16.66
Incineration	14	18.66
Other methods	17	20.00

These data are taken from the very complete final report (1921) of the conference of Metropolitan Borough Councils, of which Mr. J. T. Watson was chairman. Other methods of disposal include local dump, sorting for sale, etc. From these figures it appears that practically 80 per cent of London's house refuse is at present disposed of by dumping. A few quotations from the conclusion of the conference are of interest to municipal officials in this country as follows:

(a) **Dumping on the Land.**—The system of dumping crude refuse on low-lying land, in disused clay-pits and in quarries, although at present the principal means of refuse disposal, will, we believe, be generally condemned for public health reasons if for no other.

From the point of view of public health no word can be said in favor of dumping crude refuse. Nearly all rural authorities strongly object to land in their areas being used for this purpose (although they may adopt the same means of disposal), chiefly owing to the fact that at most dumps there is no organized method of covering over the top surface with suitable material, and no attempts are made to bring the land back into cultivation. Consequently there is a continual risk of nuisance being created by fermentation and the dump becomes a breeding ground for flies and rats.

(b) **Dumping in the Sea.**—This proposition has been put to us, and while, if it could be assured that there would be no return of the material with the tides, the system would have the merit of being sanitary, the cost of the necessary transport to river-side wharves and sea hoppers removes it, we think, from the sphere of practicability. There is also the possibility of long delays owing to unfavorable weather conditions.

(c) **Burning in Destructors.**—Refuse destructors have been in existence many years, and they have the undoubted advantage of disposing of the dangerous elements which develop in refuse when left to ferment and decompose.

As regards the utilization of the waste heat, this is of value for the driving of machinery for small subsidiary undertakings, such as a mortar mill, slab making, or a small electric light plant, but it appears that the variability in degree of heat produced by a destructor and the comparatively small portion of the 24 hours that it works, renders the application of the heat generated much less desirable for purposes of a power station than heat raised by ordinary fuel.

It is our opinion that the part to be played by the destructor in the future will be, not the burning of all refuse, but that part of which no further use can be made.

(d) **Pulverizing or Crushing.** — The Borough of Bermondsey installed four refuse crushers in the year 1919 on the river front. The plant deals with 320 tons per week, or 16,640 tons per year. The present cost of crushing at Bermondsey is 6s. per ton owing to the high rates of wages now paid. The staff consists of 12 men and 1 foreman. Their wages represent 51.88 per cent of the total cost of crushing. The borough engineer informs us that there has not been an extensive sale of the material and the council has paid a small charge to the contractor for removing it.

(e) **Salvage of Usable Constituents of Refuse.**—The suggestion was made at one of the meetings of the conference that Mr. J. C. Dawes, Inspector of Public Cleansing of the Ministry of Health, should be invited to give us his assistance in our task. This was done. Mr. Dawes has attended most of our meetings, and we are indebted to him for much valuable information concerning the activities of provincial-local authorities in the matter of refuse disposal, and with regard to the great possibilities connected with the salvage of refuse and the installations that have been set up in various parts of the country for the treatment of refuse for subsequent use. But although unsorted refuse is objectionable and would soon become dangerous to health, the fact remains that practically every one of its component parts separated from the remainder is a usable and useful commodity.

Salvage plants are still in their infancy, and we do not give any details as to capital costs owing to the variations possible according to the extent to which it is desired to sort the refuse and the manner in which the residue after sorting is disposed of. The cost of erecting on a provided site a plant capable of dealing with from 20,000 to 40,000 tons of refuse per annum may be estimated at about £15,000. Allowing for repayment of capital and interest and for running expenses and taking only a moderate estimated return on sales, a very considerable saving can be shown over present-day costs of barging or railing to dump.

It is not suggested that destructors and other systems of refuse disposal showing some return on working should be scrapped, but it is suggested that in some cases (and they are the majority in London) where refuse is barged or railed to dump in its crude state, the councils concerned would be well advised to give the closest and most serious consideration to the possibilities of salvage.

Mr. C. Newton Russell, chief electrical engineer to the London Borough of Shoreditch has likewise submitted thorough going reports on this subject. He states that,

The main defects in the present system are: Expense, inconvenience and annoyance, necessitated in destroying refuse in the center of densely populated areas, owing to:

(1) Flue dust troubles.

(2) Congestion of traffic.

(3) Increased cost of disposal of residue, which has risen from 2/- per ton in 1897 to 5/- per ton in 1917, and is still increasing.

(4) Want of space to deal efficiently with by-products, such as:

Flue dust.

Old tins and metal.

Bones, paper, straw, etc., and the utilization of burnt residue for the manufacture of paving slabs, mortar, bricks and road material.

He then outlines a constructive program in a suggestive way as follows:

In order to destroy and to efficiently deal with domestic and trade refuse, special types of furnaces are required, which it is impossible to have in small local plants. The remedy for this is, the author's opinion, centralization, and in order that these notes may not only be of a negative character, and only critical, but rather of a constructive nature, with a view to increased economy and efficiency, as well as provision for the future, the following suggestions are put forward:

1. Collection of refuse—Depots for tram and water.
2. Centralized destructor plant.
3. Conveyance of refuse and return of by-products.
4. Selection of site or sites.
5. Layout of plant, sidings, workshops, offices, workmen's dwellings, etc.
6. By-product department.

Research department (chemists).

Generation of steam.

Disposal of residue.

Manufacture of concrete or lime and clinker blocks.

Clinker for road-making.

7. Financial aspects.

After suggesting a further development of sorting he offers a tentative scheme that:

London should be divided into, say, four districts, with a central destructor plant on the outskirts of each area, and preferably with river frontage. As an illustration, take the eastern area from Shoreditch eastwards. A site could be obtained on the river front at Barking, or lower down. It should be connected to the local tram and rail systems so that the refuse trucks could be run right into the works. The area of the site should be ample enough to provide for:

Plant to deal with 2,000 tons per day.

Electric generating plant.

Repair work shops.

By-product works for making:

Crushed and ground clinker.

Mortar.

Concrete slabs, etc.

Workmen's dwellings.

Some American Conditions. — It should not be considered that English and American problems are similar. There are differences in the per capita production of refuse, in personal habits, in population densities and the like. Moreover refuse disposal in America is in process of development. Minneapolis, under the guidance of Mr. Engberg, City Engineer, and Mr. Jensen of the Water Department, has recently built loading stations to shorten haul, has motorized its garbage collection and is considering an increase of incinerator capacity.

Mr. John Kloren, City Engineer of New Orleans, has developed disposal by incineration only after a most careful study of haul economics. Chicago, with the Lake front still available for dumping is feeling the pinch of filled-up dumps and longer hauls. Indianapolis has developed a tractor-trailer system for ash collection to decrease the increasing costs of collection and haul. The conditions now in London and in some American cities, may come to other cities before many years. There is a limit, in most cases, in built up communities, to the nearby dump. Special methods of disposal and a comprehensive general plan for collection and haul are the necessary steps if service to householders is not to be curtailed. The wise communities are planning now the conservation of dumps.

What About Failures.—As commonly considered the term "Failure" as applied to refuse disposal projects, refers to the abandonment of a finished disposal plant representing invested capital and ready for operation. If a considerable sum of public money is put into work, and these works are not used but are allowed to disintegrate, something is certainly wrong. Many will say that such occurrences are rare, if not unknown. Let me name a few cities where some such upsets have occurred for part or all of the refuse: New York, Buffalo, Minneapolis, Chicago, San Francisco, Los Angeles, Seattle, Gary, Fargo, Madison and others.

Such upsets, however, are not the real failures. They are the symptoms of a deeper trouble. I offer for your consideration some of the causes of these upsets and plant abandonments as follows:

(a) A failure, in the first place, on the part of City officials, to appreciate the true measure of a refuse disposal project. Communication should understand that the first objective is a city of clean houses, with the construction of a disposal plant secured.

(b) A failure to secure and adopt a general plan for all the refuse disposal work including proper ordinances and kitchen cards, collection equipment and management, transfer stations, hauling equipment, dumping facilities, disposal work and the like.

(c) Failure to profit by co-operation with experts of independent judgment who can bring to the local problem the helpful experiences of other situations acquired through years of study and participation.

(d) A failure to operate the work with reasonable skill and economy.

Hind sign is always better than fore sight, but we are accumulating much experience that is of value in developing a general plan for a city and this experience should be used.

Summary.—A review of refuse disposal practice including some of the mistakes which have been made clearly indicates the need for a broader development in the solution of the problem. The final objective of a clean city should stand out and be accomplished through a sound general plan based on experience with tried methods, economically operated. The complexity of the problem is obvious.

By way of illustration my partner, Mr. Paul Hanson, has devised a chart showing the fundamental considerations in the refuse disposal problem and their many relationships. There are four principle elements to deal with and three to be satisfied, including house holders, the public, and the operation and its economy. Between these four factors namely house treatment, collection, haul and final disposal and the three elements to be satisfied there appear to be nineteen different relationships. Thus, collection is not only influenced by the house treatment and haul but also by items of cost in operation, public considerations, methods of final disposal and the like.

Out of these various relationships there is some combination of house treatment, collection, collection equipment, transfer stations, haul, disposal plants, dumps, sites and locations, business management and accounting which will produce the most favorable solution. Like all major engineering problems, but in a marked degree, the refuse disposal problem is one which cannot be reduced to mathematical calculation, but must be solved on a basis of experience by those who have had opportunity to study and co-relate this experience in a broad manner.

TABLE I.—RATE OF COLLECTION SERVICE.

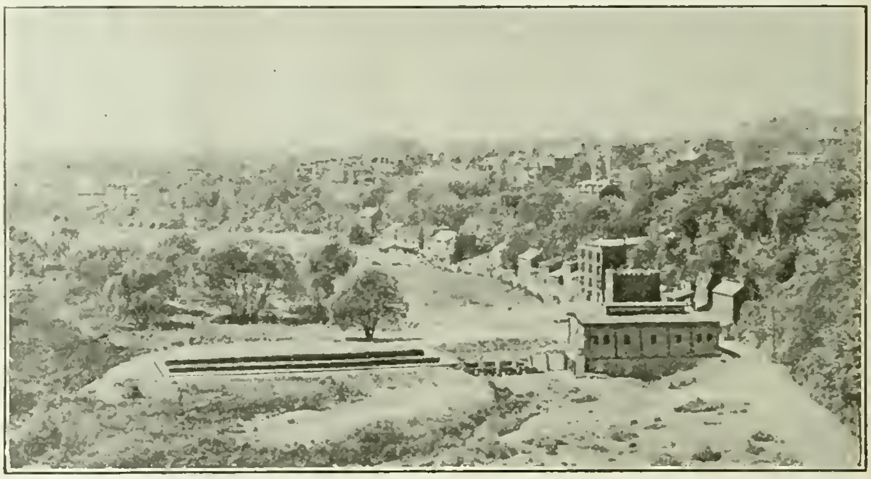
City.	Material.	No. of houses per wagon per day.
Pittsburgh	Rubbish	145
Rochester	Rubbish	167
Charleston	Garbage	250
Fargo	Garbage	210
Toledo	Garbage	275
Montclair	Garbage	300
	Ashes	200

Direct Oxidation Process of Sewage Disposal

General Review of First Year's Operation of Treatment Works at Allentown, Pa., Given in a Paper Presented Oct. 5 at Annual Convention of American Society for Municipal Improvements.

By HARRY F. BASCOM,
City Engineer, Allentown, Pa.

Early in February, 1918, under the writer's supervision, the city, through its engineering department and with the co-operation of the city laboratories under the direction of Dr. H. J. Krum, conducted an investigation of the Direct Oxidation Process which was being demonstrated at Easton, Pa. A few days later the Franklin Institute also conducted a test upon the demonstrating plant.



View of Sewage Disposal Plant and Surroundings.

Building at Right Contains Mechanical and Electrolytic Apparatus. Left of This Are Sludge Beds and Left of These Are the Sedimentation Basins.

As a result of the conclusive data obtained from both these investigations, together with the complete absence of nuisance and the small area required, and because of the extreme purity of the effluent necessary to protect the water supply of Bethlehem immediately adjoining, plans and specifications were prepared and approved by the State Department of Health Oct. 1, 1919, for the construction of a sewage treatment works embodying the direct oxidation process, "or its equivalent," at an estimated cost of approximately $200,000, which included sedimentation basins and sludge beds.

Description of Plant.—The disposal plant is located on Lawrence St., not more than 700 ft. west of the 8th St. bridge, covering an area of 0.57 acres and serves sewage districts Nos. 1, 2 and 14, from which a flow of 1,910,000 gal. per day of sewage uncontaminated with trade wastes, will ultimately be obtained, giving a maximum daily flow of 3,800,000 gals.

Screen Room.—The sewage enters the building from the street mains, then to the intake channel, then through either of two shear gates, over an inclined screen 8 ft. x 8 ft., with openings ¼-in. diameter. The solids larger than the ¼-in. opening, are retained on the screen and are brushed by five revolving brushes supported on an adjustable frame and driven by a 1 HP. motor. The speed of the brushes is about 1 ft. per second.

The screened solids are allowed to drain into the grit chambers. They are then incinerated in a 1-ton nominal capacity DeCarie incinerator, during the winter season, but during the summer season the solids are buried. The screen room is the only place where raw sewage can be seen and the only place in the whole plant where any odor can be detected.

Grit Chambers.—Under the screens are the grit chambers of approximately 270 cu. ft. capacity. From the grit chambers the sewage flows over the overflow wier, through the Venturi meter to the entrance of the electrolyzers.

Lime Tower.—At some point in the line as far ahead of the entrance to the electrolyzers as possible and between the electrolyzers and the Venturi meter, pipes are connected to admit of the introduction of the lime which had previously been crushed, pulverized and stored in the lime tower. The lump lime is received in carload lots, transferred by truck to the plant where it is put through 6-in. grids to the crusher. After passing through the crusher the lime is elevated and stored in the storage tank of 50 tons capacity. Each day when required the crushed lime is pulverized.

The lime feeders are operated by a 1-HP. motor and the equipment is in duplicate. From the effluent end of the electrolyzers, treated sewage to be used as a conveying medium for the lime, is pumped requiring a 2-HP. motor. This is discharged tangentially to the frustrum of a cone where it is mixed with the powdered lime and both is then discharged into the mixing tank or box. The lime in solution is then run into the pipe leading to the entrance of the electrolyzers where it receives the specific treatment of the process.

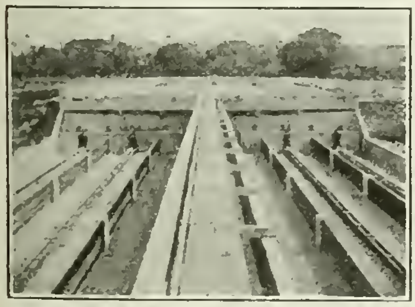
Electrolyzers. — The electrolyzing units or electrolyzers, three in number, each with a capacity of 1,000,000 gal. per 24 hours, are of the appearance of an enclosed vat 3 ft. wide, 2 ft. 9 in. high and about 27 ft. 3 in. long. The top cover in two sections is securely bolted down resting on rubber gaskets to make the vat water tight. The cover is made in two sections to facilitate removal for examination and for cleaning. From the top cover two iron pipes lead upwards several feet to conduct any accumulated gases which may collect in the unit.

The electrolyzer is mounted on vertical wooden legs and over an outlet trench of concrete through which any leakage flows to the sump pit. Underneath the units are located 14 valves for the purpose of cleaning or emptying the machine and this waste sewage also flows through the concrete trench to the sump pit. Sewage enters through a 12-in. pipe and after a travel of approximately 1 minute of time through the machine emerges through another 12-in. cast iron pipe at outlet end.

In the electrolyzer, constructed of cypress, are placed 22 sets of electrodes placed 11 sets superimposed above the other 11 sets. Each set of electrodes consists of mild steel plates 3/16 in. thick and 10 in. x 16 in. in dimensions, bolted together at the four corners. Between the mild steel plates and around the bolts are bushings of insulating materials which separates the plates ⅜ in. uniformly. The plates are so connected to and insulated that when joined in the electrolyzing circuit they are alternately positive and negative.

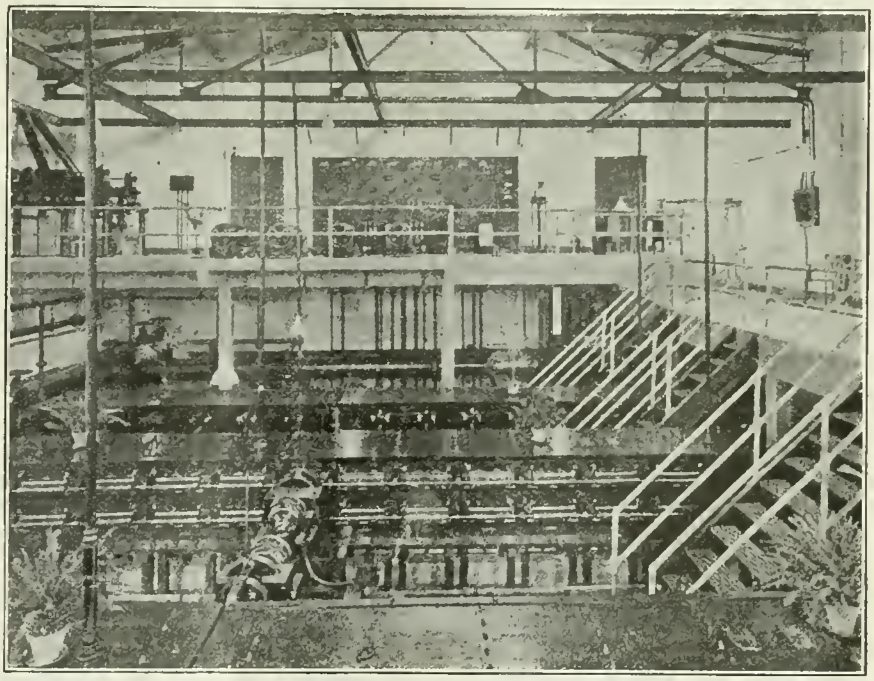
In each space are two paddles 10⅛ in. in diameter constructed of nonconducting materials and attached to shafts extending through holes in the plates.

These paddles are entirely insulated from the mild steel plates. The 22 sets of 48 plates each or 1,056 total, are set across the axis of the machine, the plates being vertical and parallel in rows. The spaces between the sets of plates and the cypress sides of the machine are blocked, thus compelling all of the sewage to flow through the ⅜-in. spaces between the plates. The entire set of paddles are driven by a 3-HP. motor through a double reduction gear box rigidly attached to the machine and to two lines of protected bevel gears on the side of the machine attached to the shafts carrying the paddles. The bevel gears operate in oil.



Sedimentation Basins and Sludge Beds.

The paddles keep the surface of the plates clear and free of sludge and debris. They also act as mechanical depolarizers. The speed of the paddles is about 20 r.p.m. At the bottom of the electrolyzer units are several valves through which any accumulation of dirt or grit which may have accumulated is drawn off.



Interior of Building of Allentown Direct Oxidation Plant.

Electrolyzing Units on Lower Floor. Beyond These at Right Is the Venturi Meter, with Its Recording Apparatus on the Gallery Above. On the Gallery, at Right, Is the Attendants' Desk; and in the Center, the Switchboards, One for Each Electrolytic Unit. At the Left Is the Lime Feed Apparatus.

Power Board.—On the slate power board are placed the controlling switches and meters, a rheostat to adjust the current delivered to the electrolyzers, a watt meter and a pole changer. The polarity of the electrodes is changed periodically to equalize the possible deterioration of the plates and to prevent the building up of the coating of the lime in any of the plates. The normal operation of the machine is at 45 to 55 volts and 50 to 55 amperes, the watt meter which registers the power to move the paddles operates under a normal load of 1,200 to 2,500 watts.

The cells in the electrolyzing unit receive a direct current from a 5-kw. generator driven by 7½ HP. motor. The paddle turning motors are 3 HP. As each plate had an area of 120.2 sq. in. per side and as the 48 plates are electrically connected so that alternate plates have the same polarity, there are 47 sides having the same polarity and each bank contains 5649.4 sq. in. of positive and negative electrode area. The total positive and negative electrode area in the apparatus which contains 22 such banks, is therefore 124,286.6 sq. in. and the total number of paddles is 2,068.

The efficiency of the apparatus becomes apparent, for it is equivalent to compelling the sewage to flow between electrodes 30 ft. high and 30 ft long spaced ⅜ in. apart in which space 2,068 paddles are revolving thus bringing every particle of sewage into intimate contact with the electrodes and thereby utilizing the oxygen and hydrogen while in its nascent or atomic state.

Sump Pumps.—Two low grade gravity lines enter the plant to the sump pit and the main trunk line siphons are frequently drained to the sump pit for cleansing purposes. The two sump pumps are each operated by 7½-HP. motors. Each pump is capable of raising 600,000 gal. sewage per day from the sump pit to the grit chamber. The pumps have electric automatic connections and with telltale attachment.

Auxiliary Equipment.—To insure operation when the central power plant may be out of service a 30-HP. Fairbanks-Morse oil engine was installed which operates a 25-kw. Ac generator. This can be started at a moment's notice. Very few times, however, was it necessary to start this unit during the year.

The entire equipment is housed in a building formerly used as a pumping station and is 42 ft. x 72 ft. in inside dimensions.

Sedimentation Basin and Sludge Beds.—From the observation flume in the main building the sewage passes to and through an elevated reinforced concrete flume 2 ft. x 3 ft. in section to the distributing flume at the inlet end of the sedimentation basin.

Here the sewage passes through eight port openings 6 in. x 6 in. in section, the openings being regulated by adjustable port regulators to either one of two reinforced concrete sedimentation basins. The dimensions of the basins are 150 ft. long by 31 ft. wide and of depth at inlet end of 7 ft. and at outlet end of 5 ft. 6 in. The capacity of each basin is approximately 230,000 gal. The basins are provided with 10-in. valves to draw off the clear liquid at the outlet ends and at the bottom of the basins are 10-in. valves to draw off the balance of the liquid which passes to the sludge beds. Six-inch valves are also provided at the front ends. The sludge is drawn from each basin by gravity through five underdrains and through five 10-in. valves.

The former site of the basin was a swamp with soft soil bottom so about 300 reinforced concrete piles 10 in. x 12 in. in dimension were constructed at the site and driven, on which to place the basin. The basin was thus anchored to prevent destruction by flood in the event that the filling around same be washed away.

Retention period in basins is from 1½ to 2 hours at full capacity of plant.

The sludge beds are 50 ft. long and 61 ft. 6 in. wide, divided by wooden partitions into six compartments. These beds are underdrained by half sections of vitrified pipe and above same is coarse stone, fine stone and coarse sand for filtering medium.

Results of Sewage Treatment.—During the past year the plant treated 73,000,000 gal. of sewage without the slightest evidence of nuisance or complaint and produced an effluent which was consistently and uniformly stable and of low bacterial count. The sewage is a normal sanitary sewage and its composition as well as the average composition of the effluent is shown in the following table:

RESULTS OF SEWAGE TREATMENT.

	Raw Sewage P.P.M.	Effluent (1 hr. set) P.P.M.	Percent change.
Suspended Solids—			
Total	150	69	—54
Volatile	110	46	—58
Oxygen consumed	17	8.1	—53
Free ammonia ...	21	13	—33
Nitrogen—			
Dissolved	10.4	7.7	—26
Total	24.0	14.6	—39.1
Chlorine	117.0	123.0	+ 5
Alkalinity (as $CaCO_3$) ...	287.0	50*	
Bacteria—			
Total 37° C....	2,036,000	12,000	—99.6
B. Coli.	87,000	18	—99.98

*Causticity as CaO.

The sludge as removed from the sedimentation basin contains 94 per cent moisture and amounts to 21 cu. yd. per 1,000,000 gal. After 4 to 6 days' drying on the sludge beds in normal weather the volume shrinks to 11 cu. yd. and the moisture content drops to 71 per cent. Therefore when dry the sludge will amount to about 3 cu. yd. per 1,000,000 gal.

It is interesting to note that the wet sludge as taken from the sedimentation basin was absolutely free of colon bacilli, contained 44,000 total bacteria and when diluted with river water and distilled water had a stability of over 99 per cent with methylene blue in dilutions ranging from 1 to 25 up to 1 to 1,000.

During the year the sludge has in the main been satisfactorily used for filling around the plant, although in some instances truckers have carted it away and used it on their farms, and they report that it is a very good growth stimulant, soil corrector and improves the mechanical property of the soil.

Cost of Operation.—The cost of operation will vary in different localities due to the cost of power and to the hardness of the water supply. Allentown is unfortunate in this respect in that its water supply is well above the average in hardness and therefore requires much more lime than many other communities. However, during the past year accurate records of cost have been obtained and as the flow is continually increasing this data have been computed and checked and when the plant operates at full capacity or 3,000,000 gal. per day, our figures show that the cost will be as follows:

COST OF OPERATION PER 1,000,000 GALS. AT FULL CAPACITY OF PLANT (3,000,000 GALS.).

Power 213 Kw. Hr. @ 2.8 ct.........	5.96
Lime, 0.6 ton @ $9.10 per ton (86% CaO)	5.46
Operators, $135; 2 @ $125; 1 @ $100 per mo.	
Labor, laborers, 2 men @ 40 ct. per hour	7.61
Heat	.08
Light	.17
Misc. supplies and repairs	1.02
	$20.30

Giving an operating cost of $20.30 per 1,000,000 gallons.

Recent Improvements in Plant.—During the year several improvements have been made in the lime dosage, a new slaking chamber was installed and the lime added further upstream from the electroylzers giving better slaking and mixing, also effecting a saving of approximately 25 per cent in the quantity of lime used.

Lately a new type electrolyzer was installed and tested out, showing a reduction of 50 per cent in the hydraulic head required as well as an electrical efficiency considerably greater than the older type. This unit has the same effective electrode area as the older ones, but contains only a single row of 10 banks of electrodes and the agitators reciprocate instead of rotate, being driven from the top instead of the side.

Comment has been frequently made that the direct oxidation process is no more efficient than lime alone. In this connection a great number of tests have been made at Allentown both by the City Chemist and by other investigators and the results are conclusively in favor of the direct oxidation process which gives an effluent that shows a greater reduction in oxygen demand, oxygen consumed, organic nitrogen and bacteria.

These tests also showed that the effluent produced by lime treatment even though practically sterile when discharged will putrefy if mixed with river water, while that from the direct oxidation process will stand up indefinitely. When we consider the experience of the British Royal Commission where litigation arising from nuisance has invariably followed from the installation of lime preciptating plants and also the findings of the Massachusetts State Board of Health, these comments are untenable for we have yet to encounter any nuisance at Allentown.

Conclusion.—A very significant feature about the operation of the direct oxidation process is that it is mechanical in nature and depends for its success, not upon the delicate adjustment of conditions in an endeavor so far as possible to favor the caprices of bacterial life, but solely upon simple mechanical contrivances whereby lime is fed into the sewage in sufficient quantities to render that sewage always slightly but definitely caustic, and thereafter to maintain an uninterrupted charge of electric current in the electrolyzers. Outside of these features the process is automatic.

Except in the screen room where the raw sewage passes over the screens, there is no odor of sewage, stability being obtained in the electrolyzing units without production.

No odors are present outside the building even from the sludge beds. Fly and mosquito nuisances such as is always prevalent at all other kinds of sewage disposal works are unknown at the Allentown plant. A system of this type can be located at any part of the city where favorable delivery of the sewage can be accomplished, and especially where little space is available. Long, expensive trunk lines and isolation of the plant is therefore unnecessary, a great saving in dollars to the municipality.

The plant operates irrespective of weather or temperature conditions, purification being accomplished without the aid of living organisms and its operation is free from all uncertainties of bacterial activity, is not affected by climatic conditions or by changes in sewage and is positive in action.

The variation in flow of sewage through the electrolyzers up to the capacity of the unit has no effect upon the current required; in other words, any quantity of sewage up to the capacity of the unit requires the same amount of current as the rated flow.

Public Interest in Waterworks

The superintendent of a waterworks system has to deal not alone with the general problems connected with the construction and operation of his plant, but also with those of sanitation, chemistry, bacteriology, electricity and finance, and numerous other factors which may have a bearing on the operation of the plant and the business which has been instrusted to him.

We believe with a better knowledge of our water supply and their needs, instilled into the citizens of our community, a greater enthusiasm will be aroused. It will then become easier to obtain backing in the many projects for improvements which we know should go on and which so often are too long delayed.

The health and safety of every resident depends upon a proper water supply, and the time has come when the public, which owns the waterworks, should be brought to a realization of the responsibility which they entrust to officials in charge, and to recognize the importance of extending the fullest co-operation.—From the 1921 report of W. H. Lawrence, Superintendent Water Department of Kalispel, Mont.

Determination of Heating Value of Coal.—The most accurate method of determining the total heating value of a coal sample is by combustion in a bomb calorimeter, states the U. S. Bureau of Mines in Buletin 193, just issued. The instrument should be carefully standardized by burning substances of known calorific value, such as the standard samples of cane sugar, napthalene, and benzoic acid, that are now being furnished by the Bureau of Standards. The standardization should be conducted under exactly the same conditions and with the same thermometer that is used in the tests. The use of calibrated thermometers is essential. In farefully conducted calorimetric work the probable error should not exceed 0.2 per cent, which corresponds to about 30 B. t. u. in a high-grade coal. This degree of accuracy is higher than can be obtained in the usual methods of sampling, the error introduced by which oftentimes increases the total error to 100 B. t. u.

High Pressure Systems for Congested Value Districts

Abstracts of Papers Presented Sept. 15 at the 41st Annual Convention of the New England Waterworks Association Held at New Bedford, Mass.

High Pressure Systems from the Underwriters' Viewpoint

By G. W. BOOTH.

Chief Engineer, National Board of Fire Underwriters.

Losses resulting from conflagrations are those most dreaded by the insurance companies; they correspond in fire insurance to what a widespread attack of the plague would be to life insurance. It was following the Baltimore conflagration in 1904 that the National Board of Fire Underwriters organized the Committee of Twenty, superseded two years later by a standing Committee on Fire Prevention, one of the principal functions of which had been to advise on means whereby conflagrations might be averted. The Baltimore High Pressure System was installed as a result of the experience in combating the 1904 Conflagration in that city, and the San Francisco System correspondingly after the 1906 Conflagration.

Conflagrations spread either by the generation of a heat wave of such intensity that everything combustible in its path is involved, or by means of flying brands varied by the wind far in advance of the origin of the fire and setting fire to combustible roofs or porches. The first type of conflagration is that of which we must think in considering the installation of high pressure fire systems, since most of them occur in high value congested districts and it is only in such districts that the expense of installing and maintaining a separate fire main system can be warranted. There is of course much doubt as to whether such a system or any other fire fighting facility will enable a fire department to make a direct stop of a conflagration well started; probably not, since the heat wave is so intense for some distance in advance of the fire as to prohibit a stand. But it will at least facilitate a narrowing and checking of the fire at strategic points, and should serve to prevent a threatening fire from assuming conflagation proportions, as it has in fact been reported as doing in one or more cases in Baltimore.

Cities Having High Pressure Fire Systems.—An inspection of the list of cities in which separate fire main systems have been installed shows that 9 out of the 18 cities which have installed such systems with special pumping stations to supply them have a population in excess of 400,000; four of the other 9 are in excess of 200,000 and most of the others either present special fire protection problems or were able to take advantage of favorable conditions to minimize the cost of installation or of maintenance or both. In this comparison are not included those cities which have made extensions of the domestic high service systems into congested value sections at lower elevations. Such extensions have been made in Worcester, Providence, Newark, N. J., Fitchburg, Lawrence, and a few other cities, and furnishing from 3,000 to 8,000 gal. per minute at initial pressures ranging from 130 to 180 lb. must be considered as highly valuable auxiliaries to other fire-fighting facilities.

An interesting form of development is that in Atlantic City, where the high value hotel district is protected in part by a system of mains and hydrants installed by the city, with supply from the fire pumps in each of the hotels under protection. A somewhat similar plan was established a number of years ago by the proprietors of the Locks and Canals for the protection of the mill district in Lowell, Mass., and certain of the mills in Lawrence have connections from their individual fire pumps to a common main running the full length of the plants. While this plan has some disadvantages as compared with a system having supply and distribution under single management and control, it appears to be well suited to serve adjoining and common interests where the more expensive complete installation is not practicable.

Arguments for Installing System.—A few years ago, when the question of installing a system in Boston was being discussed, the National Board prepared a pamphlet entitled "The Desirability of a High Pressure Fire System in the City of Boston." We had perhaps more difficulty in convincing ourselves that such a system was desirable in Boston than in most cities of its size, in spite of its narrow streets and congestion of buildings; because the City of Boston had already an unusually good system for supplying water to fire engines, besides having extensions from the domestic High service for serving automatic sprinkler equipments throughout most of the congested value sections. The arguments in that pamphlet may be summarized as follows, and will apply with equal or greater force in other large American cities.

(1) The immense aggregations of buildings and contents in the business district of metropolitan cities, and the possibility of conflagrations involving tremendous losses and disastrous effects on business and civic growth dictate the most effective known means of preventing such catastrophies.

(2) A large number of powerful streams can be concentrated on a fire in much shorter time and with fewer men and less apparatus than with fire engines.

(3) The protection of the rest of the city will not be weakened to the extent now necessary on third and fourth alarms from the district covered by the system.

(4) It will deliver its full capacity at any point in the district covered and at any desired pressure and can sustain this pressure as long as wanted.

(5) It eliminates the confusion entailed in the operation of a large number of fire engines, tends to prevent the misunderstanding of orders and in every way simplifies operation.

(6) It provides protection to the congested value district even with a general alarm fire under headway in another part of the city, and forms an effective barrier against fires starting outside the district, while also affording the most efficient means of checking fires in the district which might otherwise involve a nnmber of blocks.

Concerning the first of these items I would not have you believe that there are no other effective and practicable means of offsetting the conflagration hazard. I recently had the pleasure of a discussion on this subject with the chairman of the London City Council Committee on Fire Brigades, which corresponds to the position of Fire Department Commissioner in American cities. He had been in New York about a week and was wondering why it was that, in spite of the vastly greater numerical and apparatus fire department strength as compared with London, we had such disastrous and destructive fires. When questioned, he stated what undoubtedly constitutes the answer to his problem, that in London the building ordinances prohibit any building more than 80 ft. high, require fire walls to subdivide floor areas, and compel the protection of all openings in elevator shafts and other connections from floor to floor. These requirements, together with protection on exposed openings in exterior walls and with automatic sprinkler equipments in buildings of hazardous occupancy, would go very far towards making entirely unnecessary the powerful high pressure systems we are considering. However, the present situation and trend of development in American cities are such that structural conditions will for many years to come require the strongest possible fire protection facilities to offset them.

Concentration of Streams at Fires.—It is not an impossibility, even without a high pressure system, to concentrate numbers of powerful streams on a threatening fire in a large area building, as has been proved again and again in the city of Boston, where the water supply is ample and readily available and the fire department trained and accustomed to do that very thing. However, it is not a very common practice nor one readily accomplished without good training, as has been demonstrated in a number of cases recently, at fires which would have been much less destructive had these powerful streams been used. It is not so difficult to accomplish for the modern department equipped with automobile pumping engines as it was in the days of steam fire engines, which are much more awkward to handle and less able to maintain the pressure and discharge at which they are rated. However, even the automobile fire engine is at a disadvantage, since the largest of those in common use has a rated capacity of 1,000 gal. per minute at 120 lb. net pressures, and we may reasonably expect from each of the closer hydrants of a high pressure system an average of 2,000 gal. per minutes at any pressure up to 250 lb. Also, such a system is much more flexible in operation as respects relocation of hose lines and regulation of pressures on individual lines than one which involves the use of fire engines.

Use of New York City System.—Since July, 1908, when the high pressure fire system was put in service in Manhattan, the most extensive use made of it was in January, 1909, when it was brought into service for five simultaneous fires, three of them of more than usual severity, and one particularly so. At the extreme, seven pumps were being operated, delivering 33,500 gal. per minute against an average pressure of 225 lb. at the pumps and 205 lb. at the hydrants. Forty engine companies were called, including more than 600 men, and all the water thrown on the fire was from the high pressure system.

The system was also used on the occasion of the Equitable Building fire, and at a difficult fire in a general storage warehouse fire on Jane St. in July 1922; because of a disastrous explosion in the early stages of this fire, it was not considered safe for firemen to remain in the building, and the fire was therefore drowned by streams from the outside; at one time 60 large streams, using a total of over 30,000 gal. per minute were in service, at a pressure of about 200 lb. at the hydrant, and a total of 87,000,000 gal. of water is reported to have been used. Each of these streams would require, if fire engines were used, the services of one fire company, whereas each company can lay and handle at least two or three lines from a high pressure hydrant to turret nozzles or water towers. It follows, therefore, that fewer companies will be required for fires calling for large quantities of water, and a much smaller part of the city will be stripped of its normal protection.

Conversely, in the event of a general alarm fire in another part of the city, sufficient companies to man a reasonable number of streams will always be left in service for the protection of the district which is covered by the high pressure system; and should a fire originate outside the district and threaten the district itself, the concentration of streams which can be effected would constitute a means whereby such an exposure fire could be checked or narrowed with better success than in any other way except perhaps by the interposition of sprinklered buildings, well provided with window protection; these latter are not frequent enough at present on the outer boundaries of most of our congested value districts to constitute a very reliable line of defense.

The High Pressure Fire System of Boston

By F. A. McINNES,

Division Engineer, Water Division, Public Works Department, Boston, Mass.

The Boston high pressure fire system, as now proposed, will protect approximately 1 square mile of territory covering practically the entire congested value district of the City. It will consist of eight pumping units in three separate stations with 19 miles of mains. It is designed to operate, if the necessity should arise, at a pressure of 300 lb. to the square inch.

Two stations with four pumping units, 11.75 miles of mains and 313 hydrants have been in service for the past seven months, furnishing approximately two-thirds the measure of protection which the completed system will afford.

A description of the existing system follows:

Pumping Station No. 1.—This is located in an isolated area, in the basement of the Lincoln Power Station of the Boston Elevated Railway Co., corner of Commercial and Battery Sts.; where the fire hazard is very slight.

The equipment includes two 3-stage double suction centrifugal Worthington pumps, each directly connected to a Westinghouse 750 H. P. steam turbine operating at 1165 rpm with steam pressure of 175 lb., asmospheric exhaust.

Two 16-in. suction mains, both connected with low service distribution system of City (pressure 55 lb.). One of them also connects with high service distribution system (pressure 85 to 90 lb.). One 16-in. suction main connects with intake conduit supplying salt water from harbor to Boston Elevated Power Station for condensing purposes. A centrifugal vacuum pump, with 75 gal. priming tank, driven by a 10 H. P. 220 volt D. C. motor is provided to prime the fire pumps when salt water is used.

Two 16-in. discharge mains each equipped with a venturi meter, extend from the station to the H. P. F. Distribution System.

A vertical centrifugal single stage sump pump, driven by a 220 volt D. C. motor, takes care of any leakage, etc., in the station.

The Mains and Valves.—The water piping is of cast iron with flanged joints, each piece of pipe in the force main being separately tested at a pressure of 600 lb. per square inch before being assembled. A 4-in. by-pass, equipped with the necessary check valves and meter, is provided between suction side and discharge side of piping to insure the absence of air in the system and to provide means of measuring the leakage in the high pressure fire distribution system.

The principal control valves on the piping system are electrically operated by Deane control. Ross regulating valves are installed between the suction and discharge of each pump by means of which the pressure at the pumps are controlled from the operating board upon which the necessary gauges and indicators are installed and from which the valves in the piping system, the vacuum pump and the sump pump are operated.

The turbines are started by hand throttel. Steam is supplied through an 8-in. loop pipe connecting to each end of steam header in the boiler room of the Boston Elevated Station, where a battery of 20 Babcock and Wilcox boilers with a total of 10,344 H. P. are located, eight to ten of these boilers being always in service.

At a test recently made by the National Board of Fire Underwriters, Pump No. 1 discharged 3100 gal. per minute at 301 lb. pressure and 4,676 gal. per minute at 201 lb. pressure. Pump No. 2 discharged 3114 gal. per minute at 300 lb. pressure; 5164 gal. per minute at 209 lb. pressure and 7400 gal. per minute at 100 lb. pressure. The two pumps operating together discharged 6580 gal. per minute at 292 lb. pressure and 10,266 gal. per minute at 201 lb. pressure.

Pumping Station No. 2.—This is located in a building constructed for the purpose within the boiler room of the Third Station of the Edison Electric Illuminating Co. on Atlantic Ave., opposite Pearl St.; fire hazard very slight.

The equipment includes two 4-stage single suction centrifugal Worthington pumps, each directly connected through semiflexible couplings, with a 750 H P. 235 volt D. C. shunt wound commutating pole Westinghouse motor with a speed range of 860 to 1050 rpm.

Two 16-in. suction mains connect with low service distribution system of city (pressure 55 lb.); one of them also connects with high service distribution system of city (pressure 85 to 90 lb.). One 16-in. suction main connects with large intake conduit supplying condensing water for the Edison Station. Two centrifugal vacuum pumps with a 75 gal. priming tank, each driven by 10 H. P. motor, are provided for priming the fire pumps when suction is taken from salt water. One vertical centrifugal single stage sump pump driven by 220 volt D. C. motor takes care of any leakage, etc., in the station.

Two 16-in. discharge mains, each equipped with a Venturi meter, extend from the station to the H. P. F. Distribution System.

Piping and Valves.—The water piping is of cast iron with flanged joints, each piece of pipe in force main being separately tested at a pressure of 600 lb. per square inch before being assembled. A 2-in. by pass, equipped with the necessary check valves and meter, is provided between suction side and discharge side of piping to insure the absence of air in the system and to provide means of measuring the leakage in the H.P.F. distribution system.

The principal control valves on the piping system are electrically operated hy Deane control. Ross regulating valves are installed between the suction and discharge of each pump by means of which the pressure at the pumps are controlled from the operating board upon which the necessary gauges and indicators are installed and from which the fire pumps, the valves in the piping system, the vacuum pump and the sump pump are operated.

Power for operating the pumps is furnished through cables extending to the pump room from the main switchboard in the generating room of the Edison Third Station in which are located four 1600 k. w. and two 800 k. w. direct current generators, and four 1000 k. w. and two 800 k. w. motor generators. The direct current generators are operated by engines supplied with steam from a battery of 19 boilers of 8400 H.P capacity, six to ten of the boilers being always under steam. The motor generators receive current at 6600 volts A. C. from the main station of the Edison Co. in South Boston, delivering it at 250 volts D. C. Three underground transmission lines extend, over two separate routes, to the Edison Third Station, any two of which have sufficient capacity to operate the entire motor generator installation in the station. Ten direct current tie lines from seven substations in the city are available, on an emergency, to supply 1500 to 1800 k. w. to the Edison Station. In addition, two storage batteries with a combined capacity of 9470 ampere hours, sufficient to run both fire pumps for a period of approximately two hours, are available at the Edison Third Station.

At a test recently made by the National Board of Fire Underwriters, Pump No. 1 discharged 3141 gal. per minute at 298 lb. pressure and 4413 gal. per minute at 202 lb. pressure. Pump No. 2 discharged 3000 gal. per minute at 300 lb. pressure and 4407 gal. per minute at 200 lb. pressure. The two pumps operating together discharged 6580 gal. per minute at 292 lb. pressure.

Distribution System.—The system was designed to deliver 12,000 gal. per minute about any block with a hydrant pressure of 250 lb. per square inch, and a pump pressure of 300 lb. per square inch. As a matter of fact, the efficiency of the system exceeds this requirement as during construction the sizes of mains were increased in several instances to provide for different proposed locations of pumping stations. One hydrant is allowed for each 40,000 sq. ft. of area; to secure this distribution, a tracing of the pipe system was superimposed on a sheet of cross section paper in which each square represented 40,000 sq. ft. In this way a sufficient number of hydrants were located to fulfill the requirements.

The system is so designed that, when completed, it will be operated under normal conditions in two parts overlapping each other, or as a duplex system. This arrangement calls for slightly larger mains, but greatly increases the efficiency in the event of a broken main or hydrant. In such a case, one system would be at once shut off at the pumping station and would remain out of service until the gates required to control the break had been closed, the other system would continue to function at full power. In other words, approximately one half the hydrants would remain in service despite a break in the system; e. g., the hydrants on two sides of any particular block would remain in service.

The system now consists of—

20,140 lin. ft. 20-in. pipe, 1.51 in. thick.

28,808 lin. ft. 16-in. pipe, 1.27 in. thick.

13,081 lin. ft. 12-in. pipe, 1.04 in. thick,

with 313 hydrants supplied by 8-in. pipe .8 in. thick.

The straight pipe and special castings are cast iron excepting branches where the opening from the run is 12-in. or over, in which case semi-steel is used. All pipes were subjected to a hammer test at a pressure of 600 lb. per square inch.

The Pipe Joints.—Two lead grooves are cast in bell end and spigot end of each pipe, and during installation of system, if it is necessary to cut a pipe, two lead grooves are required in their proper location near the end of the cut pipe.

The joint material used where unbalanced pressures exist, or might develop, is an alloy of 95 per cent lead and 5 per cent tin. Extensive preliminary tests showed that the admixture of tin increased the strength of the joint sufficiently to safely permit tie rods to be dispensed with; a conclusion that has been verified in practice.

All mains when laid, and before joints are covered, are tested for a period of one hour at a pressure of 400 lb. per square inch. For several years past no difficulty has been experienced in keeping the joint leakage below ½ gal. per lineal foot of pipe joint per 24 hours; in fact, there is usually no leakage of this kind. It is however, impossible to avoid some loss of water at gates and hydrants, and the contract test requirement adopted of 2 gal. leakage per lineal foot of joint in 24 hours is as small as is practicable.

The joints are made as follows: A small pot is kept warm floating in a larger kettle of hot lead. When the joint is to be made, sufficient lead is measured into the pouring pot and the necessary amount of block tin is added at the last minute. The caulking is done with dog tools using a two-handed 4-lb. hammer, a starting chisel and three sets of caulking chisels. The joint is finished or polished off with hand tools.

The Hydrants and Valves.—The post hydrant was designed and patented by Joseph A. Rourke, now Commissioner of Public Works of Boston. It is of rugged design with 8½-in. bbl., 6⅛-in. main valve opening against the pressure and four 2½-in. independently controlled outlets. A notable feature of the design is an auxiliary valve formed by 3-way cock operated by a covered stem extending along the side of the barrel and terminating in an operating nut at the head of the hydrant. One position of the 3-way cock closes the waste and equalizes the pressure above and below the main valve in hydrant barrel The other position opens the waste and closes the connection with hydrant barrel. The hydrant was designed for a normal delivery of 2,000 gal. per minute, the loss at this flow being less than 8 lb.

The valves, designed by the department, are of the solid wedge type, bronze mounted, bodies and bonnets of semi-steel 30,000 lb. tensile strength. All stems are of monel metal, tensile strength 80,000 lb. per square inch. Each gate was tested for strength at 500 lb. per square inch, for leakage at 450 lb. per square inch and for operation at 300 lb. per square inch.

Signal System.—Alarms are received in each pumping station on the usual tapper and gong circuits of the fire department alarm system with a perforating register and small gong on the tapper circuit and gong on the gong circuit. For signalling from fires, two special circuits connecting telephone jacks in all public fire alarm boxes (63 in number at the present time) in the high pressure fire zone to a Morse key, telephone jack and relay at fire alarm headquarters; the relays operate registers, time stamps, flash lights and sounders. Portable telegraph and telephone instruments, carried by chief officers responding in high pressure districts, are used for code signals for increase or decrease in pressure. These are repeated over a special alarm circuit connecting fire alarm headquarters with both stations; Morse keys and relays operating perforating registers and red flashlight are provided at headquarters and each station; headquarters has a tapper and time stamp and each station an 8-in. turtle gong. Orders from one station to the other for the operation of additional pumps are transmitted directly over this circuit. Fire alarm switchboards in the pumping stations are of slate, with metal mountings; standard fire station keys and switches provide testing facilities on each board.

Contractors to Organize to Obtain Open Top Cars.—A meeting open to all interests connected with the road building industry is to be held at 10 a. m., Oct. 12, at the St. Nicholas Hotel, Springfield, Ill., for the purpose of perfecting an organization to protest and if possible, prevent the yearly "hogging" of open top cars, by other industries. F. C. Murphy, 1220 Chamber of Commerce Bldg., Chicago, Ill., is secretary pro tem.

Core Walls of U. S. Reclamation Service Dams

An interesting discussion of the various types of core-walls for earth and rock fill dams is given by Mr. C. H. Howell, Engineer, U. S. Reclamation Service, in the August Reclamation Record. The notes following regarding dams of the U. S. Reclamation Service are taken from Mr. Howell's article.

Masonry Core-Walls.—The masonry core-walls built by the Reclamation Service are all of concrete and in general are comparatively thin sections. The highest in service at the present time is in the Strawberry Dam, Strawberry Valley Project, Utah. The maximum section of this wall is shown in Fig. 1.

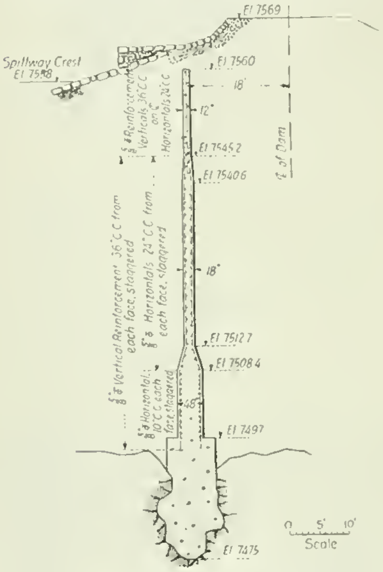

El 7569
Spillway Crest El 7558
El 7560
18'
12"
El 7545.2
El 7540.6
℄ of Dam
18"
El 7512.7
El 7508.4
48"
El 7497
El 7475
⅝" Vertical Reinforcement 36" C C from each face, staggered
⅝" Horizontals 24" C C from each face, staggered
⅝" Horizontals 10" C C each face, staggered
0 5' 10'
Scale

Fig. 1.—Maximum Section Core-Wall Strawberry Dam.

The Tieton Dam, Yakima Project, Washington, now under construction will be the highest earth dam built by the Reclamation Service. It will be an earth and rock fill section, approximately 220 ft. high with both a concrete core-wall and a hydraulicked puddle core. The puddle core will have a maximum width of 70 ft. at base of dam. It will be placed against the upstream face of the concrete core-wall. The concrete portion of the core wall extends to a maximum depth of about 100 ft. below the river bed. In general it will be founded on andesite, although a small portion will rest on shale. A minimum penetration of 5 ft. into both shale and andesite is specified which is to be increased, if necessary, according to the character of the material which may be encountered. Where the foundation is in shale the footing will be spread out to limit the pressure due to weight of the wall itself to 8 tons per square foot. The reinforcing of the spread footing will consist of 20-lb. rails at 12-in. centers. On andesite the maximum thickness will be 5 ft.

The design of the maximum section is shown in Fig. 2.

Puddled Cores.—Only two dams have been constructed by the Reclamation Service with puddle cores in the strict sense of the term and these were constructed by hydraulicking. The dams thus built are the Conconully Dam on the Okanogan Project and the Bumping Lake Dam on the Yakima Project.

The Conconully Dam was constructed by the hydraulic method, but as the fill increased in height it was found impossible to secure a central impervious portion of sufficient thickness, due to the decreasing percentage of fines and the narrowness of the pond. Loam therefore was borrowed from the valley floor and then sluiced into place between wooden forms which were placed to prevent strata of sand being washed in from the other material.

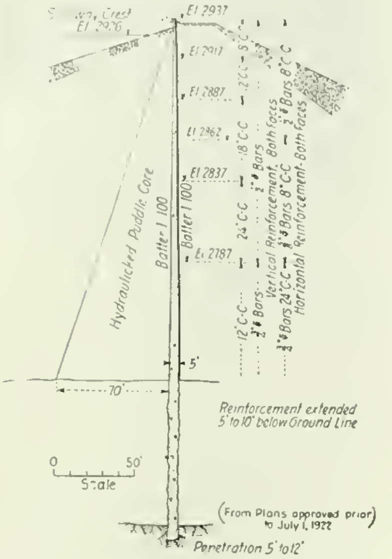

Crest
El 2926
El 2937
El 2911
El 2887
El 2862
El 2837
El 2787
5'C-C
12"C-C
18"C-C
24"C-C
12"C-C
$\frac{3}{4}$" Bars
$\frac{3}{4}$" Bars
Vertical Reinforcement, Both Faces
$\frac{3}{4}$" Bars 8"C-C
$\frac{3}{4}$" Bars 8"C-C
$\frac{3}{4}$" Bars 24"C-C
Horizontal Reinforcement-Both Faces
Hydraulicked Puddle Core
Batter 1 100
Batter 1 100
5'
70'
Reinforcement extended 5' to 10' below Ground Line
0
50'
Scale
(From Plans approved prior to July 1, 1922)
Penetration 5' to 12'

Fig. 2.—Maximum Section Core-Wall and Puddle Core Tieton Dam.

This puddle core is 8 ft. thick at its base 14 ft. above the base of the dam; the thickness at its top is 5 ft. In section this core is not vertical, but slopes upstream about 30 ft. from its top, which is under the upstream edge of the crown. Its vertical height is about 40 ft.

The Bumping Lake Dam was built by hauling the material on to the dam, then separating and consolidating it by hydraulicking, the fines being sluiced toward the center and forming a puddle core. The puddle was built by this method up to about spillway level, a distance of about 50 ft. from the bottom. At this elevation similar difficulties in the hydraulic method developed as on the Conconully Dam and the rest of the puddle material was dumped and worked by shovels. The maximum height of the Bumping Lake core is about 60 ft. The horizontal dimensions are variable; in the hydraulicked portion they range from about 20 ft. near the bottom to about 2 ft. at the spillway elevation. The portion placed by hand averages about 4 ft. thick.

The core-walls and puddle cores constructed by the Reclamation Service have proven adequately tight, and so far no trouble due to saturation has developed in the upstream portions of the dams in which they are built. Somewhat extended reading indicates that the above is generally true of other well designed and constructed dams. Both types have been in service for years and doubtless will continue to be used in the future, offering, as stated before, practical and economical solutions when more theoretically correct sections are not feasible.

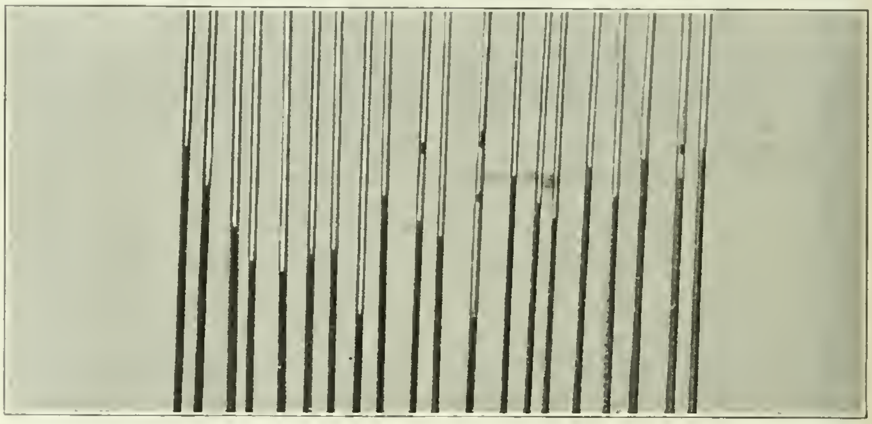
Unusual Core of Sherburne Lakes Dam.—A most unusual core was built in the Sherburne Lakes Dam by the Reclamation Service as a part of the drainage system of the dam. This drain consists of a core of screened gravel, 5 ft. thick at the top, 10 ft. thick at the bottom, and about 83 ft. high, with side slopes of 3:100. This core is placed approximately under the downstream edge of the crown and extends the full length and height of the dam. The most impervious material in the dam is placed above, the core and the coarser below. A cast-iron pipe with open joints is in the bottom of the core and connects with transverse discharge drains, which lead back into the stream.

This construction thus far has proven satisfactory, although it has not yet been thoroughly tested, having been subjected to a head of only 45 ft. and being designed for 68 ft.

Loss of Head Due to Bends

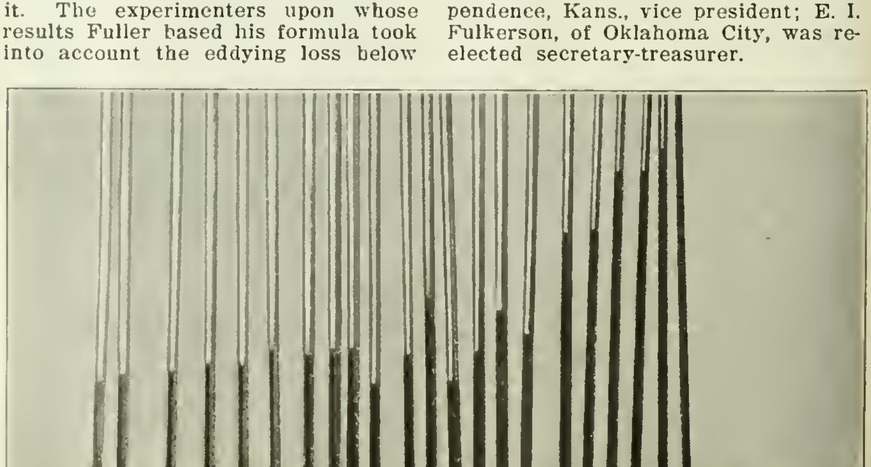
By F. W. MEDAUGH.

The present status of our knowledge as to the loss of head due to bends is probably best summed up in an article by Mr. W. E. Fuller, published in the Journal of the New England Water Works Association, December, 1913. In this article Mr. Fuller gives an empirical formula for the loss of head due to bends, based upon all of the then available experimental data. He states that all of the loss does not occur in the bend proper, but that eddying with a certain amount of loss of head probably occurs above the bend as well as below it. The experimenters upon whose results Fuller based his formula took into account the eddying loss below the bend by placing the lower piezometer approximately 100 diameters below the downstream end. Without exception, however, they placed the upper piezometer relatively close to the upper end of the bend, and by so doing, necessarily excluded from their readings any eddy losses occurring above the curve.



Water Levels in Tubes at Upstream End of Bend.

Experiments made by the writer on a number of carefully prepared bends in wooden pipe of rectangular section indicate that eddying does take place above the bend. The hydraulic gradient for the outer stream lines—obtained by inserting a row of glass tubes into the outer pipe wall—was straight for the bend proper and also at a considerable distance above and below the bend, but in the immediate vicinity of the ends of the curve, it was very irregular as shown in the accompanying illustrations. The irregularity is due, of course, to readjustment taking place in passing from a section whose pressure is uniform to one whose pressure is unbalanced by centrifugal force. The irregularity was not of a wave nature for the water levels in the different tubes remained practically constant for a given velocity. The photographs from which the illustrations were made were obtained by coloring the water with a large quantity of potassium permanganate.



Water Levels in Tubes at Downstream End of Bend.

New Officers of Southwest Waterworks Association.—At the Annual Convention of the Southwest Waterworks Association on Sept. 27, the following officers were elected: J. H. Patterson, of Oklahoma City, Okla., president; H. A. Gallangher, of Independence, Kans., vice president; E. I. Fulkerson, of Oklahoma City, was reelected secretary-treasurer.

Removal of Taste and Odor in Water Supplies

Commoner Conditions Found in Practice and Methods of Elimination and Prevention Discussed in Paper Presented at Philadelphia Convention of American Waterworks Association

By NORMAN J. HOWARD
Bacteriologist in Charge, Filtration Laboratories, Toronto, Canada.

At the present time, problems involving taste are largely confined to excessive algae growths and to the formation of chemical compounds following the sterilization of water with chlorine. The presence of iron and gases may also give rise to complaints. The discharge of various industrial wastes into rivers and streams, from which water supplies are drawn, is the cause of many difficult problems that engineers and sanitarians must solve. It is proposed to deal in this paper with taste and odor removal by aeration, filtration and chemical processes. Time does not permit elaboration on the methods of aeration and filtration in general practice, since it is assumed that aeration means the rapid exposure of water to air with a subsequent oxidation of the organic matter and the removal of excessive carbonic acid and certain odor producing gases. In general, where filtration is employed, aeration should follow the filtration process. Where odors result from gas production, or when iron in solution is present, aeration prior to filtration is preferable.

Water containing iron in excess of two parts per million will give a taste described as inky, while water containing iron and sulphuretted hydrogen give a particularly offensive odor, although the gas may be readily removed by aeration. The cause of surphuretted hydrogen in water, particularly in well supplies, may usually be demnstrated by a topographical survey. Such waters may be exceptionally pure, and, if the gas formation is not produced by the reduction of sulphates, then some inorganic reducing agent may be the cause.

In waters containing calcic sulphate and organic matter, a calcic sulphide is formed, even at ordinary temperatures, by the action of the organic matter on the sulphate. The sulphide is decomposed by the carbonic acid and sulphuretted hydrogen is liberated, which imparts to the water an unpleasant taste. Waters containing iron and gases invariably contain carbonic acid in large quantities.

When iron is in solution, as a ferrous carbonate or sulphate, aeration produces precipation, the iron coming down in an oxidized state. If iron is present in large quantities, it may be necessary to aerate the water or introduce air under pressure, and subsequently to apply lime or alum. The resultant precipitate would have to be settled out before filtration. Calcium hypochlorite has been successfully used in the removal of odors and iron, and has been shown to possess remarkable powers of oxidizing organic compounds. The whole qnestion of nuisance arising from the presence of gases and iron in solution may usually be solved by aeration and filtration processes.

Taste from Microscopic-Organisms.—Taste and odor from the presence or decompostion of microscopic organisms are world-wide. Seasonal variation in the developments of algae is more or less controlled by climatic conditions. For the purposes of this paper the subject may be divided into two groupings, bacteria and algae. The direct relation of bacteria to taste, with the exception of crenothrix, is not apparent. Bacterial decomposition causing taste and odor has followed the discharge of sewage and other wastes into rivers and streams deficient in oxygen.

The effluents from creameries are particularly offensive, forming fungoid growths which rapidly decompose and produce foul conditions. In slow flowing streams the discharge of putrescible matter is objectionable and may cause highly offensive tastes and odors. As these invariably occur during warm weather and frequently are only of short duration, the installation of aeration plants is hardly justified, and filtration alone will do much to remove the objection. Chlorine treatment will also materially assist, by preventing the putrefying conditions. Ordinarily, taste does not result from crenothrix, but this organism in the presence of iron, with which it is always associated, may produce a characteristic taste. There are cases on record where decomposition of crenothrix has imparted a distinct taste. Here again, aeration followed by filtration is effective. Filtration alone has proved beneficial not only in removing the organisms, but in reducing the iron content. Laboratory experiments, conducted at Superior, Wis., some few years ago, where the water prior to treatments was highly colored, and contained crenothrix in large numbers, demonstrated the fact that crenothrix was completely removed by the filters without aeration, but that heavy deposits on the surface of the filters caused considerable trouble by shortening the filter runs.

Taste and Odor from Algae Growths.—Complaints of taste and odor arising from excessive algae growths are frequently encountered. They are, however, somewhat easier to overcome on account of the definite cause being known. Their removal requires much skill and careful supervision. Treatment of such waters usually involves a pre-chemical application of copper sulphate or other reagents, followed by aeration or filtration. The writer feels that water conditions vary enormously and the amount of chemical found sufficient in one case may prove totally inadequate in another. In other words, the application should be based not only upon the microscopic content, but upon the physical and chemical nature of the water. The definite establishment of free and half-bound carbonic acid and of the organic matter present is of great importance, decomposition and solubility of copper sulphate being dependent upon these conditions. The number of algae causing trouble is so great and well known, that it is needless to dwell upon this subject. It is assumed that taste and odor do and will develop in all cases, when specific organisms are present in sufficient numbers. During the past few years, great advances have been made in the elimination of complaints arising from excessive algae growths. The brilliant research work of Sir A. C. Houston on the London water supply has suggested radical changes of importance. He was able to demonstrate in England that "in certain cases objectionable taste in waters resulting from algae growths could be removed by the addition of minute doses of permanganate of potassium. The dose varies with the oxidisability of the particular water involved, but in dealing with the London supply, the innocuous dose of about 2.5 to 5 lb. of permanganate per million gal. of water was found to destroy the taste in a few minutes. The faint preliminary pink tinge imparted by the addition of the permanganate rapidly faded away, and, in practice, the consumer received a tasteless water with no pink tint, but slightly browner in color than normal."

He points out that such treatment is only admissable in special circumstances. Houston's further researches demonstrate that excess chlorine or permanganate was able to remove certain tastes which frequently followed the application of chlorine for sterilization purposes.

Destruction of Organisms by Copper Sulphate.—When working on the New York supply recently Brush and Hale were able to show that copper sulphate was successful in killing large numbers of organisms including tabellaria, asterionella and synura. Chlorine was applied and caused a reduction in the the number of organisms, though not to the same extent as copper sulphate. The most interesting feature of their work was the fact that, in one case where tabellaria was found, it was shown that the numbers present were insufficient to cause taste, yet, after chlorine was applied, objectionable taste followed. In the taste resulting from synura, the application of chlorine was increased from 0.3 up to 0.73 part per million. A sample taken 1500 ft. down the stream from the point of chlorine application and tested 15 minutes after addition, showed the synura taste to be reduced and a combination of synura and chlorine taste to be present. Samples collected about 8 hours later, showed a slight chlorine taste, but the cucumber taste from the synura has disappeared. Brush states "Whether the excess chlorine oxidizes the synura oil, or forms a tasteless compound is not known, but whatever may be the chemical reaction, the important factor for water-works operators is the removal of taste." Later he adds: "The increase in copper sulphate apparently more promptly and completely destroys the organisms, and thus fully exposes its oils to mechanical removal in the flow through the aqueducts and to the later chemical reaction with the chlorine at Kensico. The increase in the chlorine does destroy to some extent the organisms, but its more important action appears to be a rapid neutralization of the synura oil through a chemical process." The work of Brush and Hale has demonstrated on a large scale the practicability of removing taste and odor by treatment with copper sulphate and excess chlorine. Their findings may be of great value in solving future problems of a similar nature.

Sensitiveness of Algae to Differences of Alkalinity.—Some interesting observations were made by Hannan in the laboratories at Toronto, to determine if algae were sensitive to differences in alkalinity, as well as to hydrogen-ion concentration. It was noted that in a water containing a luxuriant growth of algae (chlorophyceae) which was treated with normal acids: (1) enough to nearly neutralize the alkalinity, (2) equivalent to about one-third the alkalinity, marked changes occurred. In the nearly neutralized water in warm weather, growths stopped in less than 3 days, and died off, whilst in the partly neutralized sample the organism thrived. Possibly the alkalinity acts as a carrier of carbonic acid between the atmosphere, etc., and the algae. When the algae are flourishing, the hydroxyl-ions will generally be found to be high, and, as it is lowered, a point occurs where they may die off rapidly. It should be mentioned that Houston found that, in waters containing fragellaria and asterionella the addition of acid produced no ill effects upon the organisms. He states: "In some experiments the dissolved carbonic acid in the water was first neutralized, in others it was increased by the addition of traces of acid, but in neither case was any constant or appreciable difference in results observed from those just described." The explanation of these two conditions is somewhat problematical, and it may be that there is a definite range for the development of each type of organism. It is well known that different quantities of copper sulphate are required to treat different organisms and it is possible that different hydrogen-ion concentrations may also play an important part in the development and death points of these lower forms of vegetable life. This is a matter which should be demonstrated on a practical scale where opportunity occurs. If it were found that hydrogen-ion concentration controls the situation, the treatment would be simple.

Taste and Odor Following Chlorination of Water.—The greatest objection raised against the chlorination of water has been the production of taste and odor in certain supplies. This condition has at times been used as an argument against the installation of sterilizing plants, and it must be admitted that, where these objectionable conditions periodically occur, they constitute a real nuisance. In many cases taste could be overcome if authorities would make a thorough investigation definitely to establish a cause. The City of Toronto has just authorized a year's research work on this important subject, and the preliminary observations carried out are most encouraging.

The cause of taste following the chlorination of water is not definitely established. Yet the removal of the cause of certain controlling conditions, observed at Milwaukee and elsewhere, has resulted in the elimination of taste. In treated waters two types of taste occur, a chlorine and a medicinal taste. The latter is sometimes described as resembling iodoform. Each taste generally occurs separately.

The writer has no record where chlorine and iodoform taste have been reported present at the same time. Often excess chlorine smells and does not taste, but the iodoform compound both tastes and smells, particularly when the water temperature is above 50°F. The cause of the chlorinous taste is, as the word implies, due to excess chlorine, while the cause of the iodoform taste is said to be due to the presence of chloro-phenols.

Extensive observations made by the writer have not convinced him that this is the sole cause, although it must be admitted that phenol in small quantities does combine apparently with chlorine to form chemical compounds which produce offensive taste and odors. Laboratory work carried out during the past few months has produced some surprising and at times puzzling results. It has been assumed generally that the presence of organic matter was essential for the production of iodoform taste in chlorinated water.

In distilled water treated with taste-producing doses of chlorine and phenol, the characteristic iodoform taste is not produced, but a pronounced chlorinous taste results. If this same water is passed through a rapid sand filter, the organic matter or some unknown substance taken up by the water produces most offensive taste and odor. Inversely, slow sand filtered water after treatment with chlorine and phenol develops a taste which is greatly lessened, however by its passage through the same filter

When in Europe last summer, records were shown to the writer indicating that the presence of organic matter and phenol was not necessary for the production of the iodoform taste. A deep well water of great purity and free from phenols had received some slight surface water pollution and consequently was chlorinated. The well formed part of a supply for a large community and, after treatment with a small dose of chlorine, a pronounced iodoform taste resulted. One is forced, therefore, to the opinion that, while organic matter and phenols contribute to taste production, in certain cases there must be other causes which act in a similar taste-producing manner.

In support of this, it should be pointed out that, at Toronto, where industrial wastes are discharged into the city sewers all the year round, and extensive tests are daily made on the raw water, the iodoform taste occurs largely in the early spring and late fall. If phenol were the only cause of this taste, objectional conditions would prevail throughout the year. The obvious answer is that, at certain low temperature periods, some other organic or vegetable matter combines with chlorine or phenol or both and these compounds produce the conditions complained of.

It is also possible that, if phenol is the direct cause, increased biological activity in the warm summer months assists in preventing the formation of obnoxious chemical compounds. Before discussing the iodoform taste in detail, it would be well to dwell briefly upon the chlorinous taste or odor, which not infrequently occurs under two conditions: first, in water comparatively free from pollution, and, second, in water where too great a quantity of chlorine has been applied. The elimination of the first named condition is practically impossible, except by aeration which is neither practical nor necessary. Water containing a small excess of chlorine, particularly when the temperature is low, has a slight odor when first drawn from the tap, but this rapidly disappears upon exposure to the air. In waters containing chlorine in excess of the amount necessary for sterilization purposes, both taste and odor exist. Tea made from such water will have a most objectionable taste due to the action of the chlorine on the extractive matter present. As is the case when phenol is present, it is possible that some similar compound is formed by the combination of chlorine and tannin. The chlorine absorption method, as suggested by Wolman and Enslow, is very practical. As several observers have reported the elimination of taste since using this system, it would seem well worthy of adoption.

Chlorinous Taste Reduced by Establishment of Color Standards.—In Toronto, the establishment of color standards was found to reduce greatly the chlorinous taste. The dosage necessary for sterilization purposes was worked out, and the blue color produced by definite doses of chlorine, in the presence of starch and iodide, was matched artificially. By making up color standards numbered 1 to 5, and establishing the fact that colors 3 to 5 were sufficient to sterilize the water under varying conditions, chlorine operators were instructed to keep their dosage within these color ranges. This is not put forward as a solution for taste elimination. Since its adoption in Toronto, however, the number of complaints has been greatly lessened. The colors do not represent any definite quantity of applied chlorine, but generally speaking colors 3 to 5 reperesent approximately an application of 0.175 to $.225 parts per million of chlorine with a water temperature ranging between 33° and 45°F. As the water warms chlorine is absorbed more rapidly and with a temperature of 68°F, it may be necessary to apply 0.375 parts of chlorine to maintain a color of 3 to 4. The organic content and temperature of the water will be found to control practically the rate of chlorine absorption. The formula for preparing the color standards is as follows:

Standard Number.	Distilled Water. cc.	0.01 Per Cent Brilliant Mill Green. S. cc.	0.01 Per Cent Cardinal Red. J. cc.
1	150	4	0.866
2	150	5	1.053
3	150	6	1.10
4	150	7	1.15
5	150	8	1.25

The standards should be made up weekly, placed in China cups and protected trom the light. In all taste producing conditions there must be controlling factors and often it is difficult to avoid taste without taking chances on the final quality of treated water, particularly where it is unfiltered.

Houston's Observations Regarding Iodoform Tastes.—By far the most serious taste to overcome is the iodoform one, because, when the taste has once developed, its elimination is difficult. In general, water which tastes after treatment with chlorine improves on storage, but, when the iodoform taste is present, it steadily deteriorates, and should it warm up, a chemical odor can be detected. In connection with the production of this taste, Houston's remarks as recorded in his Fifteenth Annual Report are of considerable interest. He states:

> His experience has indicated that the iodoform taste can practically always be removed or prevented, either by increasing the dose of chlorine sufficiently, or by adding potassium permangantes as well as chlorine to the water. In the former event, the excess of chlorine may

have to be removed by dechlorination (solution of sulphurous acid gas, sodium sulphite, bisulphite, or thiosulphate) and in the latter case it is desirable to remove the precipitate of manganese oxide. The permanganate can be used before, at the same time as, or after the addition of chlorine, that is, it can be used either to prevent the occurrence of the iodoform taste, or to remove it after it has already developed. Similarly, the whole of the super-dose of chlorine may be added to the water at one time, or more chlorine may be added to overcome an iodoform taste, which has already occurred in a chlorinated water. Enormous doses of chlorine (one in 11,-600) may be added to water and the taste of chlorine entirely removed by the use of a suitable anti-chlor (de-chlorination). When, however, the chlorinated water has developed the iodoform taste, de-chlorination is powerless to remove it.

One of the most important observations made was that, when dealing with filtered water, chlorine or permanganate could be used before, or after filtration, or chlorine added before and the permanganate after filtration, but the addition of permanganate before and chlorine after invariably produced an iodoform taste. The experiments as conducted by Houston usually involved several hours contact. In this country, this condition is difficult to attain since the water often passes into use almost immediately after treatment. This, of course, does not apply to cities where the supply comes from impounding reservoirs or where the works are located outside the city limits. The cause of the iodoform taste has been the subject of extensive research. The officials of the City of Milwaukee are credited with being the first to demonstrate the relationship of phenols and chlorine to the production of taste. During the past few years in Toronto, extensive investigations have been made upon taste-producing conditions. Numerous hypotheses have been advanced from time to time and have included the microscopic content, the biological content, the formation of chloramines and latterly the formation of chlorophenolic compounds. The relation between microscopic and biological content and iodoform taste has not been demonstrated, although when taste does develop, there is often a pronounced increase in both conditions in the raw water. Similarly, abnormally high free ammonia has periodically occurred at these times and the formation of chloramines has been suggested. This latter compound of ammonia and chlorine actually produces an objectionable taste and smell when occurring under pollution conditions. Curiously enough, when chloramine is used as a sterilizing reagent, no taste occurs.

Tests at Toronto.—Daily tests have recently been made in Toronto to determine the phenolic content of the raw and filtered water. Results have shown that when the water was polluted with sewage containing industrial wastes, phenol was present in quantities up to 0.012 p.p.m., the average figure in March and April being 0.00173 and 0.0021 p.p.m. in two intakes respectively. The first named figure was reduced by slow sand filtration to 0.00083 part and the latter figure to 0.0011 by the drifting sand plant, an approximate reduction of 50 per cent. The slow sand system gives a slightly higher removal. Iodoform taste occurred in the city water with residual phenol content of 0.006 p.p.m. when only 0.2 part of chlorine was applied. This actual condition confirmed the laboratory experiment described later in this paper. Generally speaking, laboratory tests, when using a small rapid sand filter, have shown a remarkable decrease in taste with and without the application of aluminum sulphate.

Owing to the uncertainty as to the controlling factors in iodoform taste, one is compelled to deal with established conditions, which at present time are limited to phenol. The estimation of phenol when present in small quantities is difficult, methods at present in use giving unreliable results. The system as devised by Trowbridge at Newcastle, Pa., would appear to be the best in use, but the writer has not always been able to completely recover amounts of applied phenol when using his method, or to secure satisfactory blanks. When working in the Toronto laboratories, using Lake Ontario water, we have been able to establish the definite dosage of chlorine and phenol which combines and forms the iodoform taste. The chief point established is that the critical figure which causes taste is close to the actual dose of chlorine applied in many cities, thus explaining why taste so often occurs.

It should be clearly understood that the results were obtained when treating Lake Ontario water. In other waters, with varying chemical contents, different ranges might be recorded. Briefly, it may be stated, that applied chlorine in doses up to 0.1 p.p.m. does not produce taste in combination with phenol, when this latter substance is present in quantities up to 0.015 p.p.m. Doubtful tastes may occur when chlorine is added in amounts between 0.135 and 0.150 part with phenol present up to 0.015 p.p.m. The critical dosage range occurs when chlorine is added in amounts between 0.175 and 0.4 p.p.m., with phenol ranging between 0.002 and 0.017 p.p.m. An actual combination of 0.22 part of chlorine and 0.007 part of phenol caused a water which both tasted and smelt badly of iodoform. In most of the experiments the taste, when it had once developed, became steadily worse, and in one instance after ten days was still pronounced. Chlorine applied in doses in excess of 0.65 part per million completely eliminated the iodoform taste, when phenol was present up to 0.017 p.p.m., but a faint chlorinous taste was left. In this series of experiments, involving several hundred tests, two definite points were established, first that, in the presence of small amounts of phenol, an iodoform taste developed when 0.175 p.p.m. of chlorine was added, and, second, the taste persisted until the amount of applied chlorine reached a dosage of 0.65 p.p.p.

Having demonstrated that chlorine in excess would take out the iodoform taste, experiments were made to see if increased doses of phenol would act in a similar manner. Chlorinated water containing 0.2 part of chlorine were treated with phenol in doses ranging between 0.010 and 0.064 p.p.m. The water thus treated was almost undrinkable, both tasting and smelling of iodoform. Before passing to other considerations, it should be stated that work carried out in Toronto confirms Houston's work in England, namely, that excess chlorine will completely remove iodoform taste. Assuming, therefore, that the excess chlorine treatment could be successfully applied to most supplies where tastes and odors occur, the problem would narrow down to one involving the determination of the amount of chlorine necessary and the subsequent removal of excess chlorine. Where aeration is possible de-chlorination would in most cases be unnecessary. This would be dependent, of course, upon the amount of chlorine originally applied and absorbed. Radical changes, such as excess chlorine treatment involves, will necessarily alter certain operating conditions, as filtration and sterilization processes. In connection with these, excess chlorine taste and odor could be removed without affecting the quality of the effluent by chlorination prior to filtration. Filters of any kind have remarkable chlorine absorption powers, due in parts to their retention of organic matter. For various reasons engineers do not favor this practice, but the writer sees no reason, particularly where mechanical plants are involved, why chlorine could not be applied to the water after sedimentation and prior to its passage through the filters. This would apply, of course, only at times when the excess chlorine system was in use for relieving conditions. At Toronto, chlorination prior to filtration has been found to work efficiently and to give satisfactory results. No attempt has been made to use the excess chlorine treatment, but it will in all probability be tried out this summer. Laboratory experiments have demonstrated, however, that filtration does decrease the iodoform taste, and, if the application of chlorine may be so controlled that this taste is not allowed to develop, there should be no reason why the chlorinous taste could not be removed by application before filtration. The removal of excess chlorine by chemical reagents depends entirely upon local conditions. If the location of plant and the quality of the water are favorable, there is no reason why this system could not be undertaken, if it is borne in mind always that technical supervision is essential. The success of the treatments has been demonstrated by Houston.

Removal of Iodoform Taste by Excess Lime.—Recently, the removal of iodoform taste by excess lime, has been tried in Toronto. While the experiments are not yet sufficiently advanced, preliminary observations are not favorable. It was found, however, that the taste was reduced, but not eliminated, when using large quantities of lime. The combination of the characteristic taste produced by excess lime in water, together with the iodoform taste, rather masked the true taste. Three separate observers were able to detect the iodoform taste after a twenty hour contact period. Water treated with chlorine, phenol, and lime, and having a doubtful taste, was passed through a rapid sand filter, when a pronounced iodoform taste resulted, thus confirming the opinion previously expressed that lime only masked the iodoform taste. Taste occurring in the treated water at a temperature of 60° F. was less pronounced than at 15° F.

The experiments as conducted by the Milwaukee Sewerage Commission under Hatton and Copeland and described in the 7th Annual Report of the Commission are of particular interest. Ammonia condensation liquor was found to contain as much as 0.144 per cent of phenol (carbolic acid). In the experiments with ammonia condensation liquor, containing 0.078 per cent of phenol and other taste producing compounds, it was shown that one part of the liquor produced a taste in 40,000 parts of chlorinated Lake Michigan water. The a.c. liquor was added to sewage entering an aeration tank in quantities ranging between 0.8 and 9.1 per cent of the sewage flow. No taste of consequence was delivered in the effluent except on one or two occasions. At such times the taste was so slight that, when the effluent was diluted with lake water no taste could be noticed in the diluted sample. The conclusions were that, under warm weather conditions, the activated sludge process of sewage purification will remove the carbolic acid taste in sewage, which contained ammonia condensation liquor equal to 2 per cent of the sewage flow. And for that reason it is concluded that the sewage disposal plant should protect the water supply from taste produced by ammonia condensation liquors discharged into the sewers. The absence of taste in many cities during the summer months might be linked up also with this condition, as, where industrial wastes are discharged into sewerage systems, marked seasonal biological activity occurs, which may have much to do with taste prevention.

Salt Velocity Method of Measuring Flow of Water in Pipe Lines

Experimental work in measuring the flow of water through pipes by injecting salt solution and timing its trend gives promise of an accurate method for measuring water, according to a paper by Prof. Charles M. Allen, presented last March at the Hydroelectric Conference at the Engineer's Club in Philadelphia.

Briefly, this method requires the introduction of salt at the upper end of the pipe line and the introduction of two electrodes at a known distance down the pipe line usually at the lower end, or the introduction of salt solution at the upper end of the pipe line and the use of two pairs of electrodes located at a known distance apart further down the line. Telephonic communication between the introduction station and the electrical instruments connected with the electrodes gives means for timing the discharge of the salt in the solution. Or for more accurate work autographic recording electrical instruments used in connection with the chronograph may be used. Alternating current of 110 volts is applied to the electrodes and the current is measured on a suitable ammeter. The ammeter usually shows an initial reading depending upon the acidity of the water and the size and clearance of electrodes.

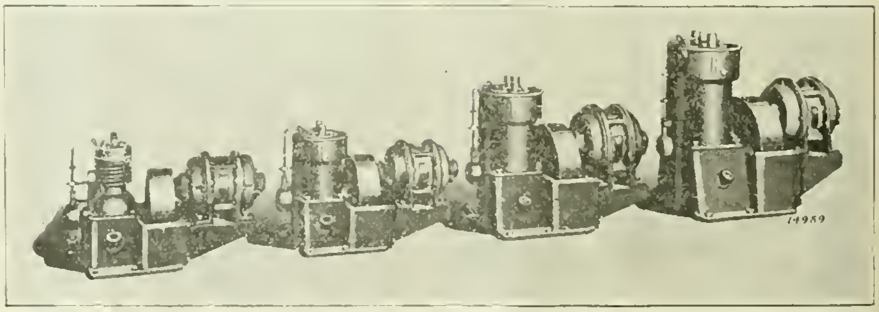
By the use of stop watches and telephone or the autographic registering ammeters, the first appearance or initial time, time of maximum density or conductivity and final appearance are determined. The time of initial appearance and of maximum density are accurately obtained, but the time of final appearance is indefinite and difficult to correctly determine. The mean time which involves the time of final appearance is therefore unreliable while the time of maximum density appears to give the actual mean velocity from all tests made so far.

Tests have been made in 13 feet wood stave lines 1,400 feet long and in a 40-inch steel riveted pipe 400-500 feet both before and after cleaning.

From these tests it is evident that time of maximum density gives the correct time independently of length and internal condition of pipe, but the ratio of initial time to time of maximum density is independent of the length on pipes of lengths thus far used. This ratio seems to vary with the pipe factor which is the ratio of mean to center velocity. The pipe factor varies with the size and internal condition of the pipe and slightly with the velocity of flow. The time of maximum density minus the time of initial appearance or period of increase varies inversely as the pipe factor and velocity of flow and varies directly as the length of the pipe.

New Line of Small Vertical Air Compressors

A new line of small vertical belt driven air compressors has been brought out recently by Ingersoll-Rand Co., 11 Broadway, New York City. In addition to the plain belt drive design each size is built as a self-contained electric motor outfit, driven through pinion and internal gears as shown in the illustration, or by employing the short belt drive arrangement. The compressing end and electric motor of both gear and short belt drive units are furnished mounted on a common sub-base, so that they are in no way dependent upon the foundation for correct alignment. Several noteworthy features of construction have been incorporated, of which the "constant-level" lubrication system is the most important. Others include the constant speed unloader for plain belt drive machines, the centrifugal unloader for start and stop control machines and the increased size of the water reservoir cooling pot. The "constant-level" system used in these Type Fifteen compressors automatically maintains a constant-level of oil, which insures the right amount being distributed to all parts. The constant speed unloader controls the unloading of the compressor by automatically opening the inlet valve when the receiver pressure rises above that at which the unloader is set to operate. When the receiver pressure has fallen a predetermined amount, the unloader automatically releases the inlet valve and allows the compressor to return to work and thus build up the receiver pressure again. The centrifugal unloader allows the compressor to start under "no load" such as is essential when automatic start and stop control is used, and permits the electric driving motor to come up to full speed before the load is thrown on automatically. This unloader accomplishes its purpose by holding the inlet valve open until the motor has reached full speed. The smallest size is built with either ribbed cylinder for air cooling, where the service is intermittent, or a water jacketed cylinder of the reservoir type for constant service. All other sizes are only built with the water jacket of the reservoir type. The size of these reservoir pots is very generous, and one filling will be found sufficient for long periods of operation.



Self Continued Electric Motor Units of Vertical Air Compressions.

Locating and Stopping Suck Hole Leaks in Rock Filled Dams

An interesting account of the methods of locating suck holes and filling them without employing costly diving apparatus appears in a recent issue of Popular Mechanics. In locating the holes two men in a boat, hitched to a cross-river rope, work their way back and forth from one bank to the other. For the exploration work, the boat is equipped with an electric light of about 200 watts. The lamp, incased in a waterproof marine socket, is lowered from one side of the boat until it nearly touches the river bed. The man on the other side of the boat watches, through a marine telescope, for traces of eddy currents. The process is continued until the entire area above the dam has been explored. After the leak is found, it remains to determine its shape and size. The material used for filling the hole depends on the size of the subterranean tunnel. For small channels, small fieldstones or small boulders are sufficient. In larger tunnels it becomes necessary to lower sacks of cinders and sometimes concrete into the orifice.

The best and most permanent method of stopping these leaks is to first let down small stones, loaded in tin cans, and, if necessary, force brush and other objects into the opening, until observation determines that the obstructions are actually lessening the flow. A few sacks of cement or cinders on top of these will finally eliminate the suction. The whole should finally be sealed over with a 2 or 3-ft. covering of concrete, spread over an area of at least twice that of the leak.

Determination of Gas in Boiler Feed Water.—Work is being done at Pittsburgh, Pa., by the U. S. Bureau of Mines on a portable method for determining the dissolved gases in boiler feed water, especially hydrogen. Some boiler feed waters have been found to contain more than 30 per cent hydrogen.

Railways and Excavation Issue

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Estimating Depreciation

With the rapid development of public utility regulation during the past twenty years, the subject of depreciation has assumed an importance altogether in excess of any that was previously given it; and of the present great accumulation of literature on the subject, by far the larger part is the work of appraisers. That a subject of such undoubted importance to operators was left for the appraisers chiefly to study and develop was but the result of a very general failure to give to the broader subject of engineering economics the attention which it warrants.

While it can not be claimed that the last word upon depreciation has been said, the recognition of certain fundamentals will go far toward stopping the confusion and disputes still frequently arising.

There are two distinct, though closely related, subjects commonly referred to as depreciation. The first is that of accrued depreciation, or total reduction in value which a property has suffered up to a given date. The second is the amount of depreciation occurring annually, for the replacement of which, financial provision must be made if the property is not to suffer ultimate destruction without recompense to the owners. Each of these subjects is marked by two major divisions—the theory on which depreciation is to be computed, and the method by which its amount under any theory is to be measured. It is the latter of these divisions of which we speak chiefly here. There is a theory, or more properly, a formula, known as the "Unit Cost of Depreciation Formula," set forth in both Gillette's Handbook of Cost Data, and Gillette and Dana's Handbook of Mechanical and Electrical Cost Data, which affords a complete and mathematically correct method of estimating depreciation. The number of factors in this formula is rather large, and the fact that in certain cases they cannot all be determined has discouraged some in attempting its use; but such discouragement fails to recognize that some of the factors usually balance one another very closely or that they are otherwise of very minor effect on the result. As a matter of fact, in a great many instances the "Sinking Fund Formula" affords an amply close approximation to the "Unit Cost Formula." The "Straight Line Method" also may be used correctly but is often subject to misinterpretation.

In the measurement of depreciation two supposedly antagonistic methods have commonly been used, and much controversy has arisen over their relative merits. These are the so-called "Age-Life Method" and the "Inspection Method." Under the former it is assumed that property of a given class has a certain normal life in service, and that by deducting its attained age from its normal life, its remaining life may be found; and with these data depreciation is estimated by whatever formula may be desired. The objections to the method are that "normal life" for most classes of property is quite uncertain, and that the life of a particular piece of property will often vary greatly from a true normal or average in even the comparatively few cases where the normal can be determined. Special and local conditions, character of maintenance, etc., greatly affect the life of almost any property; and the unskillful use of the "Age-Life Method" without due reference to these factors has led to such highly absurd results as the giving of almost no value to a brick building 49 years old, in good condition and giving good service, simply because the normal life of brick buildings of that class had been established at 50 years.

By the "Inspection Method" in its original and simplest form, one skilled in the art examines the property and reports that a certain part of its total useful service is gone, or that a certain part remains. These parts are usually expressed as "Percentage Depreciated" or "Percent Good." When made by skillful men, an inspection estimate of depreciation is much to be preferred to an age-life estimate. It avoids such obvious errors as that of the brick building mentioned, and also less glaring errors of the same character, which are really more dangerous because less conspicuous.

The simple "Inspection Method," however, has its weaknesses. The inspector is not always able to give an accurate account of the reasoning which leads him to an expressed conclusion, and he may in some cases make substantial errors if he works simply by "hunch," or "judgment," which he cannot explain, and fails consciously to take into account the facts on which depreciation actually depends. Furthermore if he is to be called in court, an inability to tell explicitly how he obtained his results is likely to prove diastrous.

As a matter of fact, depreciated condition depends upon age and life in just the relation stated in the "Age-Life Method"; while the errors which are blamed upon this method are for the most part due to the failure of particular cases to agree with the normal lives used in the formula, and usually obtain from "Average Life Tables"

Such tables have proper uses, but not usually in the estimating of accrued depreciation.

Depreciation, then, is to be estimated on an age-life basis, but not without the assistance of inspection. Normal life is a fundamental factor, but it must be the normal life under all the conditions of each particular case. Such normal life is a necessary subject of study and estimate in each case, and though it cannot always be determined accurately, the general figures of average life tables must be used only when they are known to be applicable.

In making the estimate a standard normal life must be set up for each plant unit on which depreciation is to be computed.

Obviously the life will depend upon the quality of construction, the use which is expected to be given it, and its maintenance. After a property has been in service for a time it may be observed to be of either better or poorer quality than is usual with its class of construction, and its depreciation and value will be affected accordingly. Similarly both use and maintenance in the past may have been different from what are now to be anticipated, and these facts will have their bearing on the estimate.

The various calculations commonly made, and the errors to which erroneous methods may lead are well illustrated by the case of a piece of pavement which recently came under the editor's observation. This was an ordinary type of brick pavement on a concrete foundation. Engineers most familiar with the construction use, and local conditions involved, considered 2 years as a fair normal life for such a pavement in that place. The pavement is 10 years old, and by the simple application of the age life formula its life is accordingly one-half gone, leaving it in a 50 per cent condition. Inspection discloses that for some known and some unknown reasons it is in a better condition than a new pavement laid now could be expected to be after 10 years; and it is estimated that it has a remaining life of 15 years. This 15 added to its age of 10 years gives it a total estimated life of 25 years. Forty per cent of its life is gone, but 40 per cent is not a correct measure of its depreciation in value. If it were new today its estimated total life would be 20 years instead of 25 years.

Since the best estimate which can be made on the basis of careful inspection and all other evidence indicates a remaining life of 15 years, the condition of the pavement is such as would be expected at an age of 5 years instead of at its actual age of 10 years. The case is like that of two men at the age of 40, one of whom retains his health and a good measure of youthful vigor, while the other is half way on the road to final senile decay. The correct depreciation of this pavement is then 5 years from a total normal life of 20 years, or 25 per cent. Another pavement located not far from this one is 8 years old, and has an estimated remaining life of only 4 years, so that in spite of its lesser age its depreciation amounts to 80 per cent.

The foregoing is a statement of fundamentals only, but if these are carefully adhered to estimates will be within reason, and the highly inconsistent results which many depreciation estimates have had will be avoided. To refine the estimates, maintenance, repairs, replacement, alternative construction and other factors should be considered; while to expedite the work, the experienced estimator will combine suitable groups of plant units, eliminate minor factors and use such averages as are proper; always keeping his calculations clear and his data explicit even when they are estimates based entirely on personal judgment and experience.

The Salaries of Librarians

To the Editor: I have read with interest the first article in Engineering and Contracting for Sept. 27, "If Andrew Had Organized the Carnegie Libraries Co., Ltd.," and would say that the suggestions come home to me with considerable emphasis.

I have time and again said that the librarianship of Congress ought to command a salary of something like $50,000 per year, provided the library system of the country were organized in connection with it; but have not got very far with that suggestion, though I think I see daylight ahead from the growing interest in business libraries, and the tendency to look on these libraries as earning factors.

G. W. LEE,
Librarian, Stone & Webster.
Boston, Mass.

Shrinkage and Swelling of Embankments

To the Editor: On page 64 of your issue of July 19, 1922, appears an article on "Natural Shrinkage and Swelling of Railway Embankment." This subject is of interest to our superintendents as they often have to reconcile the difference between excavation and backfill, or between bank measurement of excavation and team measurement of spoil.

We note that your article states that fill containing the greatest percentage of rock shows the greatest swell. This seems strange unless there are a lot of unfilled voids. We note that what was a 7.768 per cent swell in 1912 has become a .362 per cent shrinkage in 1920. How much of this is due to settlement and how much to erosion? Would not fill with rock be less apt to be carried away by erosion?

We have found from 12 per cent to 15 per cent difference between records of excavation based on team and truck capacity and those based on cross section. Allowing for inaccuracies in team and truck measurements our experience would check fairly close with your 1912 data.

C. E. PATCH.
Aberthaw Construction Co.
Boston, Mass.

Reduction of Contract Price for Lessened Work

Editorial in The Canadian Engineer.

Contractors have on many occasions voiced a protest, sometimes in the law courts, at the practice of diminishing the contract price for a piece of work on the basis of the reduction of quatities multiplied by the unit prices for extras given in the tender. The majority of contracts as now framed make no other provisions than that reduction of work is to be so considered. The result is that under certain extreme conditions the contractor, may be seriously penalized through no fault of his own.

If, for example, a contractor figures on the removal of 25,000 cu. yd. of earth, he plans upon a certain equipment deemed most suitable for the quantity and the conditions surrounding the work. His price is named with that equipment and those conditions in mind. If, however, the work is greatly reduced, it may no longer be practicable to install the more elaborate equipment planned for, and the cost of moving the earth per cubic yard may consequently be considerably increased. The price that was named for the larger quantity, therefore, is properly no longer applicable to the reduced quantity, and in case of reduction, the stipulated price for extras cannot properly be applied.

Again the price for extras frequently has to be made somewhat higher than for a unit of the main work planned for and comprehended at the outset. For example, if one hundred concrete piles are to be used in a foundation and the contractor has ordered the material and manufactured these, it would cost considerably more per pile to make an additional half dozen piles that may be ordered by the engineer as an afterthought or an extra precaution. It may be necessary to send a motor truck to a city many miles away to obtain the particular reinforcement required and the cost of these extra six piles may be very much greater than for any other six piles in the main work. The price for extras, therefore, being sometimes higher than for the same quantity of the main work would work a double hardship on the contractor in the case of reduction of quantities. If it be unfavorable to reduce the contract price on the basis of unit prices for the main body of the work, it is much more unfavorable to do it on the basis of unit prices named for extras.

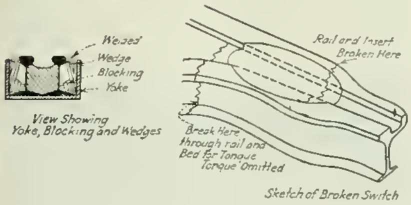
Recognition of the principle involved has been made in a number of cases of corporations with experience in handling the situation caused by extras. Thus, the Department of Works for the City of Toronto in certain instances allows for the reduction of the control price on the basis of the price named for extras reduced 15 per cent. This practice at once provides for the lessened efficiency occasioned the contractor by reduction of work and for the fact that the prices for extras may for some items be higher than for similar units in the main body of the work.

Railroads in Canada.—The total railway construction in Canada, which was some 2,300 miles at the time of confederation, and had risen to some 17,000 miles by 1897, has increased to more than 40,000 miles, not including sidings or double trackings.

Method of Repairing Broken Switch Without Interrupting Operation

Broken special work of any type causes anxiety and at best any repairs made are chiefly of a temporary nature, in the shape of a relief, until the new pieces arrive. How a repair job of this kind was successfully handled without interrupting traffic is described in a recent issue of Electric Traction by John H. Doerr, Roadmaster, The Connecticut Co.

Confronted by the report that a switch piece was causing trouble, a bolted tee rail switch with manganese insert was found broken in two places. One place was about midway of the tongue, disclosing one rail and the cast bed for the tongue broken; the other, about midway of the manganese insert, disclosed the opposite rail and the insert broken.


Welded
Wedge
Blocking
Yoke
View Showing Yoke, Blocking and Wedges
Rail and Insert Broken Here
Break Here through rail and Bed for Tongue
Tongue Omitted
Sketch of Broken Switch

Sketch of Broken Switch and Method of Repair.

The pieces were all moving freely when a car passed over, and it was then noticed that the tongue was also broken in two places.

A yoke was forged U shaped of 1 in. soft steel, the base (inside) being the outside dimensions, base to base, of bolted switch, the sides being 5½ in. high (6 in.-60 lb. rail). This yoke was forced up under the base of the switch and wedged tight against the ball of the rail at the surface of the switch. The welder was then restored to and the yoke welded to the rail. This was done at each break, after which the manganese insert was removed, cleaned, set and re-babbitted. Following this the manganese insert was welded with a hard steel to the rail on either side. In the meanwhile the tongue had been removed and a new point forged on, same being ground to fit.

This switch has seen several months' service since these repairs and will soon be replaced by the new piece ordered at the time of the break. For temporary repairs the yoke has been used similarly at broken cast welds and at broken frog pieces of the solid type with equal success.

Educational Classes Conducted by Chicago Chapter A. A. E.

The Educational Committee of the Chicago Chapter, American Association of Engineers, last winter inaugurated three educational classes for the benefit of the membership. There were no fees of any kind charged, the courses being experimental and the services of leader and lecturers being given free.

The aim of these courses was to better fit the engineer for certain positions to which he has been in the past often called, and for which his education and training are believed to fit him to perform the more important functions, but in the application for such positions he has been hampered by the narrow departmentalism of his training. They were aimed to broaden his outlook and to familiarize him with such features of the work as was outside the training of the engineer.

Course No. 1 was called "Railroad Management" and took up all the features of that work. The first lessons were in the work of a station agent. A railroad station is a miniature of a railroad as to operation. The students were next started on a railroad section. A railroad section is railroad maintenance in miniature. Due to lack of text books at a reasonable covering the subjects much of the teaching was from the platform, and the students were assigned work corresponding with what they would be called on to do as a station agent, a yardmaster, a trainmaster, a superintendent, and as a section foreman, a master carpenter, roadmaster and a division engineer. It started with 24 members and about twenty took all of the lessons.

Course No. 2 was called "Railroad Economics" and followed the general lines of a similar course in the Extension Department of the University of Wisconsin. It failed to attract a satisfactory number of members to warrant its continuance.

Course No. 3 was "City Management." It was a venture in an unknown field, as but one course was known to have been attempted previous to this one. As there is small literature on the subject, it was conducted by lectures and practical work. It was thought the lectures should be such as would supply the engineer with information first of all upon the problems with which he was unfamiliar. The course as far as completed covered:

General Problems of City Management, 3 lectures.

Charters and Municipal Corporations, 3 lectures.

Budgets and Budget Making, 4 lectures.

Taxation and Revenues, 5 lectures.

Public Accounting and Financial Reports, 4 lectures.

Civil Service and Personnel, 2 lectures.

Purchasing, Storage and Issuing of Supplies, 2 lectures.

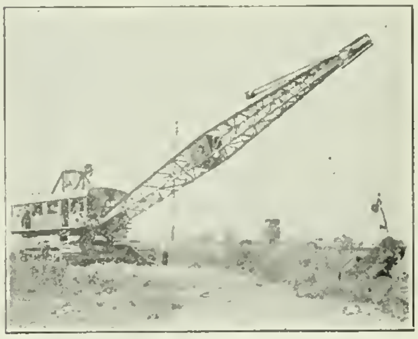
Owing to the general excellence of its published report, that of the city of LaFayette, Indiana, was taken as a basis of study, the city charter of Lima, O., as a model, and the laws of Illinois as to cities and villages were studied. A city budget will be worked out by the class, and the problems of city government studied in the light of the above named data.

This class started with twenty members, increased to 24, and held a satisfactory interest to the end of the season.

The committee was well satisfied with the season's experiment and classes 1 and 3 were reopened in September. One other class will be added if the interest taken justifies it. Three subjects have been submitted to the membership for a vote, "Engineering Administration," "Business Administration" and "Building Superintendence," the one receiving the most applicants will be taken up.

A New Dragline Excavator

The Austin No. 12 Dragline, shown in the accompanying illustration, embodies in its design and construction many new features. In general the excavator is of the full revolving type and is mounted on two multipedals. A 6-cyl. heavy duty type gasoline motor provides 250 H. P., at 425 r. p. m., which power is more than ample to drive the machinery under all circumstances. Semi-Diesel engines can be substituted if necessary. An air compressor and storage tank, the former operated through a direct connection to the main motor, provides air for the air rams, which control the drag and hoist drums, the swinging mechanism of the machine and an air starter for the main motor. Since machines of this type are worked continously day and night, powerful electric lights are installed, so that the work of excavating can proceed without interruption. Extra large multipedals provide in a machine of this class a bearing pressure of 1150 lbs. per square foot, which is sufficient to enable the machine to travel on its own power over extremely soft surfaces without the use of mattresses or artificial supports of any kind. Standard equipment is 2½ cu. yd. Page bucket and 60 ft. boom. Longer booms and smaller buckets or shorter booms and larger buckets can be furnished. This type of machine, on account of its adaptability for swamp work, is now giving an excellent performance on reclamation work in Florida. The machine is extremely mobile, having a low speed forward of ½ mile per hour, and a high speed forward of ¾ mile per hour. The wide-faced multipedals enable it to travel over the Everglades quickly and without miring. The machine is very fast in operation and records of 2,400 yds. in 10 hours have been made with it. As an example of the pains taking care exercised by the manufacturers in their efforts to produce a machine finished in every detail, it might be of interest to add that an electric fan has been provided on machines going into hot southern climes, which serves both to cool the operator and blow mosquitoes away.

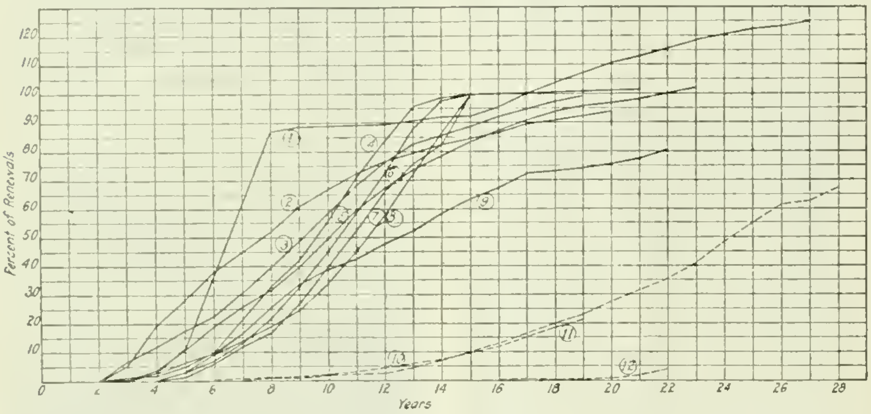


Austin No. 12 Dragline.

Grade Crossing Accidents.—During the first nine months of 1921, 873 occupants of automobiles were killed in grade crossing accidents, as compared with only 99 in all other classes of vehicles in such accidents. In 1920 1,201 occupants of automobiles were killed in collisions with trains at grade crossings.

Tie Preservation on Danish Railroads

At the present time all but one railway in Denmark uses pressure treated ties. Rational impregnation of ties was introduced in that country over 30 years when a plant was established at Koge on the Baltic Coast. The activity of this plant was very restricted during the first five or six years as only the state railways used treated ties, and that only on the lines on the Island of Zealand. In 1899 the second plant was built at Horsens. Some interesting information on the results obtained by the Danish Railroads from the use of treated ties is given in a paper by A. Collstrop, of Denmark, translated by M. P. Jensen, and published by the U. S. Forest Products Laboratory, Madison, Wis. The matter following is taken from the paper.



Renewals of Untreated and Treated Pine and Beech Ties on Danish State Railways.

(1) Originally built with green Pomeranian pine ties. Renewals made with treated Pomeranian pine ties. (2) Originally built with green Swedish pine ties. (3) Originally built with green Swedish pine ties. Renewals made with treated Pomeranian pine ties. (4) Originally built with green Swedish pine ties. Renewals made with treated Pomeranian pine ties. (5) Originally built with green Swedish pine ties. Renewals made with specially treated Pomeranian pine ties. (6) Originally built with green Swedish pine ties. (7) Built with green Swedish pine ties. Renewals made with treated Pomeranian pine ties. (8) Originally built with green Swedish pine ties. Renewals made with treated Pomeranian pine ties. (9) Originally built with green Swedish pine ties. Renewals made with treated Pomeranian pine ties. (10) Average renewals of treated pine ties, as well as some beech, years 1889-1918. 11. Originally built with Pomeranian pine ties. (12) Originally built with treated 5-in. by 10-in. Dantzig pine ties.

A mixture of zinc chloride and creosote oil has been used from the first in Denmark for timber treatment. During the war, however, it became necessary to resort to treatment with dinitrophenol, sodium-silico-fluoride and crude naphthalene. Both dinitrophenol and sodium-silico-fluoride are salts soluble in water. Both substances possess good decay-preventing qualities, but their defect, as in the case of all salts used for impregnation, is that in the course of time they leach out. There is also to be considered the inconvenience arising from their use by reason of the fact that the wood after full-cell impregnation is heavy and wet, and must remain piled for a considerable time before it can be used. Another difficulty in the use of sodium-silico-fluoride is that it is hard to dissolve, necessitating the use of very warm liquid to obtain sufficient penetration.

As is known, the various salts are not adapted for impregnation to beech. Only tar oil should be used for this species of wood, whereby it acquires an excellent durability. For lack of tar oil a limited number of beech ties were impregnated with crude naphthalene. Naphthalene, however, was found too difficult to handle since it stiffens even at quite high temperatures and the treatment of beech with it was soon discontinued.

Records of Tie Renewals.—The Danish State Railways Administration has for years kept record of the renewals of impregnated ties from year to year. The number of renewals show also the number of ties taken out during the year. An essential number of these ties are, however, presumably untreated, since of late years they have not been kept separate. However, the figures from which the accompanying curves were made represent in the main the true conditions.

The renewals represent both beech and pine. For 1908 the beech ties impregnated with a mixture of chloride of zinc and tar oil, a practice affecting the renewal unfavorably since these beech ties have lasted hardly more than 10 years. The beech ties are now impregnated exclusively with tar oil and the result is an excellent tie, provided it has no red heartwood. In renewal, all ties are considered damaged which have been renewed for mechanical reasons.

In the reports of the State Railways, in the peninsula of Jutland and the island of Funen, the number of ties renewed annually was estimated in accordance with the number of ties in stock at the close of the fiscal year with the following results:

	Per cent.
In 1897-1898	6.77
In 1898-1899	7.24
In 1899-1900	6.50
In 1900-1901	6.53
In 1901-1902	8.23

In 1900 the treating plant at Horsens was started and the annual renewals in recent fiscal years for the Danish Kingdom are as follows:

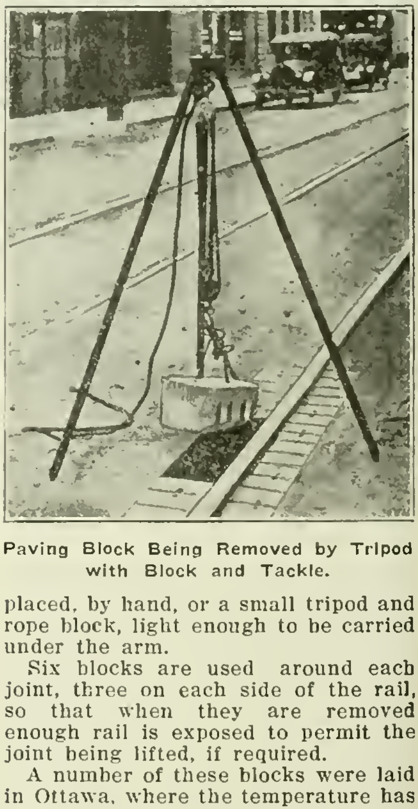
	Per cent.
In 1913-1914	3.20
In 1914-1915	3.05
In 1915-1916	2.98
In 1916-1917	3.11
In 1917-1918	2.50
In 1918-1919	2.26
In 1919-1920	2.48

These records show among other things that in the renewals for ordinary maintenance of late years only about 115,000 ties have been used, as compared with 300,000, which would have had to have been renewed if the annual renewal requirements had remained as high as they were initially. While this result is due, to a certain extent of course, to the many improvements in surface construction of late years, as tie plates better ballast, use of screw-spikes, etc., it is principally the result of impregnation.

New Paving Block for Track Joints

A paving block designed to fit around track joints and thus do away with the need of extensive ripping up of pavements in lifting a joint, invented by Mr. McL. Hunter, Roadway Engineer for the city of Ottawa, Ont., is described in Electric Traction.

The blocks can be made of concrete or wood, and, as shown in the illustration, are shaped to fit various sections of rail, the bolt heads and nuts fitting into cavities in the block. The block remains in position by its own weight, and can be readily removed, or replaced, by hand, or a small tripod and rope block, light enough to be carried under the arm.



Paving Block Being Removed by Tripod with Block and Tackle.

Six blocks are used around each joint, three on each side of the rail, so that when they are removed enough rail is exposed to permit the joint being lifted, if required.

A number of these blocks were laid in Ottawa, where the temperature has almost as wide a range as in any place on the continent, falling to as low as 30° below zero, in the winter months. The blocks came through last winter without any disturbance from frost, and were easily removed, this spring, without affecting the adjacent pavement.

Causes of Accidents in Construction

The combined records of seven members of the Construction Section, of the National Safety Council, compiled by Miss Mary A. Townsend of the Irwin & Leighton Co., Philadelphia, and reported to the section at the recent annual congress, show the following distribution of causes of lost time accidents:

Handling materials—26 per cent.

Falls of persons—20 per cent.

Falling objects—12 per cent.

Use of hand tools—11.5 per cent.

Stepping on or striking against nails—11 per cent.

Machinery and equipment—7 per cent.

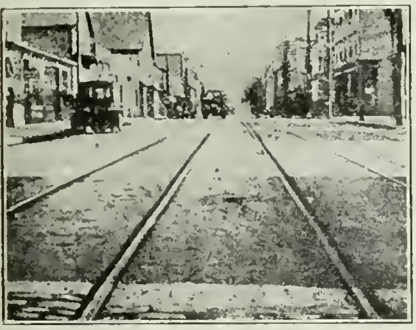
Miscellaneous causes—12.5 per cent.

Track Construction in City Streets

Methods of Eastern Massachusetts Street Railway Co. Described at Winter School for Track Men of the Company

By H. C. PACKARD,
Division Engineer, Eastern Massachusetts Street Ry. Co.

In the early nineties the 9-in. girder rail came into use, and it was so much more satisfactory for construction in paved streets than the old tram rail, T-rail or 6-in. girder rail on stringers that it was thought the rail might hold up until it was worn out. We have all seen the failure of the old type of construction as formerly laid on this system, consisting of the 9-in. girder rail laid on 7-ft. ties with bolted joints, gravel ballast and block paving with sand joints. A new standard of construction is to be adopted on all first class city tracks. To begin with, we are going to break away from the 9-in. girder rail, except where the paving to be laid by the municipality consists of a deep block, and adopt the 7-in. 91-lb. T-rail, as this type of rail will give longer life and better results.



7-in T-Rail Track With Flangeway Made by Placing a Stick Against the Rail and Paving to the Stick.

Preparation of Road Bed.—In all new track in permanent pavement, broken stone ballast is to be used and the subgrade for this is to be made 6 in. below the bottom of the tie except in a few cases where very poor material may be found in the subgrade. In this case the depth of broken stone will be determined for this particular job. The subsoil in the territory where we have paved tracks is such that it is not necessary to lay subsoil drains.

After the excavation has been made to the proper subgrade, the bed is rolled with a tandem roller, then the broken stone, consisting of stone which will pass through a 1½-in. screen, is spread and rolled with the tandem roller until the stone is well compacted.

The ties, which are to be hewn creosoted hard pine measuring 6 in. x 8 in. x 8 ft., are to be laid upon the broken stone ballast 2 ft. on centers, except at joints where they are to be 18 in. on centers, keeping the right-hand edge in a double track on line, leaving the irregular ends between track. While it does not make a great deal of difference on this type of construction, if the men get in the habit of doing this on paved track they will be more likely to be careful and see that the ties are lined up on open track, where the general appearance is unsightly if there is no pretext to line the ties. Care also should be taken that the ties are laid square to the rail, and the spikes are upon the same edge of the tie and the outside spikes upon the opposite edge of the ties.

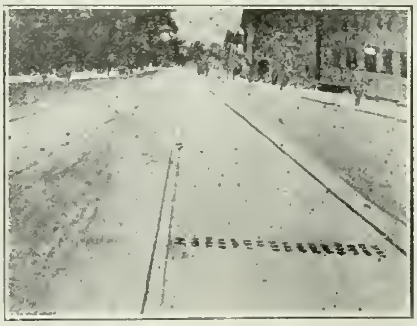
Tie plates measuring 6 in. x 10 in. x ⅜ in. are to be used with the hard pine ties in all cases.

Fastening the Joints.—A 7-in. 91-lb. T-rail is to be used with a 26-in. angle plate. The rails are to be laid with tight joints square across on tangents and breaking at the center of opposite rails on curves. After the rail ends and joint plates have been cleaned, the joints should be made up by using common grade track bolts, one at each end of the plate and in the holes nearest the joint, no bolts to be used in the other two holes in the plates; the joints are then to be made up by a gradual tightening of all the bolts until the plate is up firm.

After the track has been lined and rough-tamped, the plates should again be tightened, the joint plates are then seam welded at all four seams, the weld to be carried to a point about 1 in. from each end of the plates.

Tie rods measuring 2¼ x 13/32 in. x 5 ft. 2½ in. are to be used; the spacing should be 5 ft. on centers. The rods are to be square to the rail and the maximum allowable distance out of square is 2 in. When necessary to make new holes they are to be drilled, and not burned with the acetylene torch, as it has been found that hairline cracks radiate from the hole when they are burned, and we do not want to give the rails any chance to split through the web.

Ties Must Be Carefully Tamped.—The track is to be carefully lined, the tamping to be done with stone picks, provided no air or electric tampers are available. Great care should be taken to see that all ties are properly tamped and the track in good line before it is filled in to the subgrade for the pavement. This subgrade is to be determined by the type of pavement to be laid by the municipality.



T-Rail Track, Showing Catch Basin.

The municipalities are, of course, to lay all pavements and we are not interested in the matter, except to see that the subgrade is properly made, and that the general surface of the pavement agrees to our standard, namely, at the center between rails the pavement is to be level with the ball of the rail, and at the gage line to be level with the bottom of the ball, or a proper flangeway made for the wheels by chipping the block on granite block pavement, or by a flangeway stick in case of concrete pavement. The pavement between tracks on a double track is to be ½ in. above the top of the rails at the center between tracks.

Particular attention is to be paid to the pavement around catch basins. We have a great many broken grates and in a number of cases the pavement drops from the standard section one foot away from basin to the frame grade, causing a bad pound from any heavy vehicle passing over it, especially the heavy auto trucks. This grade should run out in from 18 in. to 24 in.

All rails are to be ground with a reciprocating grinder after the track has been completed to avoid any variation in the surface of the rail ends.

The same type of construction is to be used where a 9-in. girder rail is laid owing to the municipality laying a block that is too deep for the 7-in. T-rail; the only feature to look out for is proper subgrade for the ballast and paving foundation.

Record September Construction Activity

Building contracts awarded during September in the 27 Northeastern States (which include about three-fourths of the total construction in the country) amounted to $271,493,000, according to The F. W. Dodge Co. This figure is 11 per cent. greater than that for September, 1921, and is the highest recorded September total. The seasonal decline is still under way, last month's construction activity being 16 per cent. under that of the preceding month.

The year to date has broken many records. The total construction started during the first 9 months, which has amounted to $2,634,365,000, is greater than the total for any entire year previous to 1922. On the 9 months' basis this year is 51 per cent. ahead of last year.

Residential building showed a slight increase in September, amounting to $101,428,000, or 37 per cent. of the month's total. Public works and utilities amounted to $50,379,000, or 19 per cent.; business buildings, $45,907,000, or 17 per cent.; both classes showing increases over August. Industrial buildings amounted to $26,384,000, or 10 per cent. of the total; and educational buildings, $21,213,000, or 8 per cent.

Contemplated new work reported during the month amounted to $330,801,000.

Tests of Recent Detonating Compounds.—The explosives chemical laboratory of the U. S. Bureau of Mines at Pittsburgh, Pa., is now making comparative tests on detonating compounds and mixtures that have been developed recently. Tests will be made to determine the sensitiveness and to note whether they may be made more safe to manufacture, handle, and transport than materials now in use.

Large Orders for Rails.—Rail buying during the last week of September is stated to have given the steel trade the most active week in railroad material it has ever known. The large amount of business was due to the placing of orders at the $40 price, which on Oct. 1, was replaced by $43. In the Chicago district orders were placed for about 500,000 tons of rail, while in the east nearly as much was reported.

Dam Construction in New England

Structures Containing Nearly 5,000,000 Cu. Yds. of Earth and Rock Now Being Built at Whitingham, Vt., and Hope, R. I.

Two large dam developments involving extensive earth moving operations are now under way in New England. One of these dams is located at Whitingham, Vt., and is being built for a hydro-electric project. The other dam is at Hope, R. I., and is to be part of the new water system of the city of Providence, R. I.

View of Dam Site at Whitingham, Vt., Showing Operations on Lower Third of Dam.

Davis Bridge Dam at Whitingham, Vt.—W. F. Carey Co., Inc., has the dam contract, from the Power Construction Co., which has several hydro-electric developments in New England.

Mason & Hangar have the power house contract, including penstocks which will carry the water through an adjacent mountain before delivering it to the turbines, an expedient which greatly increases the head. Their work started early in September.

The Rollin Construction Co. had the contract for the diversion tunnel, through which Deerfield River is being diverted during the construction of the dam. Their work has been completed. A part of the tunnel will serve as a spillway for the completed dam.

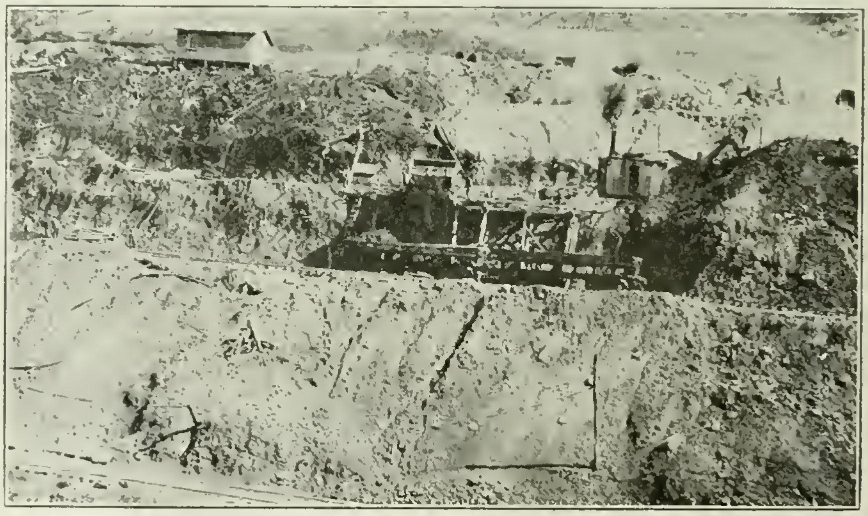
The W. F. Carey Co., Inc., started their work April 23 and must complete it before the close of 1923, in time to impound the spring waters of 1924. The dam is to be 204 ft. high from river bed to crest; 1,500 ft. wide at the bottom; 25 ft. wide at the top. It will contain 1,850,000 cu. yd. of material.

For purposes of construction the dam is divided into thirds. The upper and lower thirds are ordinary fills. Four steam shovels have been at work on both sides of the river simultaneously, loading 60 Western 12 and 16-yd. dump cars. A large Bucyrus dragline also is being used with skips.

The center third of the dam will be washed into place from the dumps on either side, by means of two large pumps, standing on pontoons. The river bed in the center third is being excavated down to a proper rock or clay foundation and all boulders, stumps, etc., removed.

Finding borrow pits is one of the problems in this mountain district. Excavated rock from the diversion and penstock tunnels is used in the upper and lower thirds. Mason & Hangar have been loading their tunnel material into Western 4-yd. dump cars, which are pulled to position by horses and dumped into W. F. Carey's standard gage Westerns, standing on the mountainside below.

The dam will create a lake 200 ft. deep and 7 miles long. In consequence the little railroad which serves Whitingham, Wilmington and Readsboro is being moved up the mountainside.

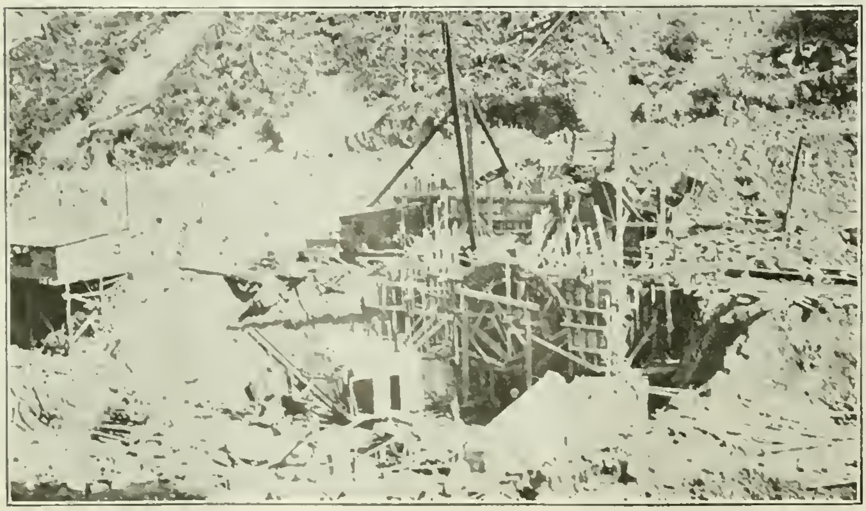


Dumping Material Excavated From Tunnel Into Cars for Use In Dam.

About 200 men are employed during the working season. They are bunked in 24 Armour refrigerator cars, which were found very cool and comfortable during the summer weather. E. J. Purcell is general superintendent in charge of the dam construction. W. R. Walters, secretary and treasurer of the company, is in charge of the office at Whitingham. J. J. Baker and Robert F. Olds are engineers on the job, representing the Power Construction Co.

The J. G. White Corporation are consulting engineers.

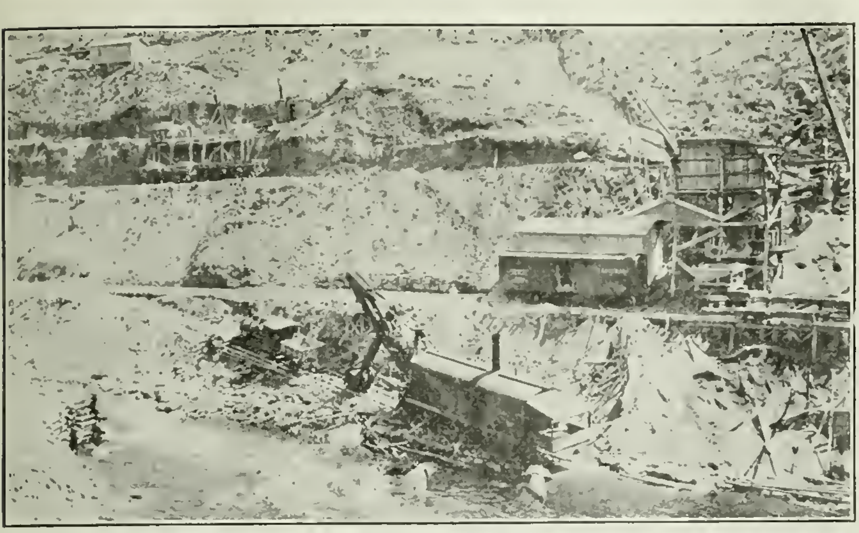
Winter, of course, will interrupt the work.



Intake at Hydroelectric Development at Whitingham.

The Scituate Dam of Providence, R. I.—Winston & Co., Inc., are building the Scituate Dam at Hope. This is an important unit in the plan laid out by the city of Providence for extending its water system. Their contract amounts to $3,500,000. Work began in June, 1921, and the time limit is November, 1925.

This dam is to impound the waters of Pawtuxet River. The city of Providence already had built a diversion dam around the site of the deep ex-



Upper Part of View Shows Work on Mason & Hangar Contract; Lower Shows Work on Carey Contract.

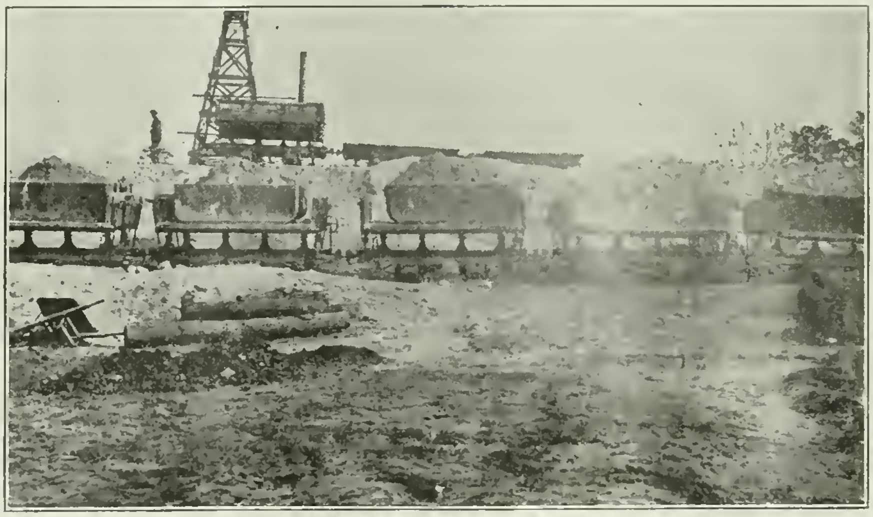
cavation, when Winston & Co. began operations. The contractors had to construct a standard-gage spur track from a connection with the New York, New Haven & Hartford R. R. at Hope, to the dam site, a distance of two miles.

There are 10 steamshovels excavating for the big fill—Bucyrus, Osgood and Erie. 150 4-yd. Western dump cars and 11 dinkey locomotives are used in hauling.

The soil is sand and gravel, filled with boulders and large patches of quicksand, necessitating a maximum excavation of 80 ft. to reach solid rock foundation. There are 350,000 cu. yd. in this deep excavation, 10,000 yd. of which are boulders of from ½-cu. yd. to 63 cu. yd. The shovels work over the quicksand on slabs from the contractor's sawmill. Drainage through the shovel-cuts leads to 5 sumps, from which the water is pumped by 6-in. centrifugal pumps electrically operated. The average amount of water drained from this pit has been 4,000,000 gal. daily.

Cofferdams had to be built both above and below the damsite, the latter on account of back water from the mills. The cofferdams were small earth embankments taken from the first material excavated and placed to form an integral part of the permanent dam.

The main dam will consist of a core of selected soil, rolled in 6-in. layers, containing 600,000 cu. yd. of selected topsoil and subsoil stripped from the reservoir basin. The remaining 2,500,000 yd. consists of miscellaneous material wet down. In placing the selected soil the shovels first excavate to a depth of 8 to 10 in., the earth being delivered to spoil banks in dump wagons, an average haul of 200 ft. The spoil banks are located in pairs and built 10 ft. high. From there the material is unloaded into dump cars.



Train of Western Cars Carrying Skips Handled by Cableway at Scituate Dam.

After the grade of the service track became too steep for the use of dump cars the material was handled in 4-yd. skips. The side doors were removed from the 4-yd. Westerns and a skip placed on each car. These skips are loaded by steamshovel. Trainloads of these skips are pulled to within reach of a traveling cableway moving on tracks 500 ft. long, paralleling the axis of the dam. The loaded skips are swung out over the pit, one at a time, and dumped from the full height of the cable.

Sand and gravel for concreting comes to the derricks in wagons, and is handled by clamshell bucket for the separation of sand, gravel and boulders, and then delivered to dump cars.

About 400 men are employed, the camp containing 65 buildings, including a hospital, central commissary, laundry, barber, cobbler and tailor shops and hydrants for fire protection. Sewage is chemically treated. Ice is supplied daily from Providence.

There are 53 children in camp who attend school in Hope, being transported both ways. M. J. Look is in charge of the work.

Building Up Core of Scituate Dam with Selected Material.

Stone Quarry Accident in 1921

Accidents at some stone quarries throughout the United States in 1921, resulted in the death of 100 employes and the injury of 10,465 others, according to figures compiled by the U. S. Bureau of Mines. The average number of men employed in quarries was 77,185, who worked a total of 17,987,547 shifts, an average of 233 work days per man. Based upon a standard year of 300 days, the reports show a fatality rate of 2.00 per thousand employes and an injury rate of 174.55. For 1920, the corresponding rates were 2.31 killed and 145.51 injured. Accidents during 1921 were distributed as follows, according to kinds of stone quarried: cement rock, 20 killed and 2,233 injured; granite, 18 killed and 940 injured; limestone, 58 killed and 5,248 injured; marble, 6 killed and 406 injured; sandstone and bluestone, 3 killed and 374 injured; slate, 4 killed and 385 injured; traprock, 11 killed and 879 injured.

Electrification of Midi Railways in France

The First System Outside of the United States to Adopt 150,000 Volts for Its Main Transmission

The lines of the Midi Railways are mostly located in the South of France north of the Pyrenees. As far back as 1906 the management of the railways commenced an exhaustive study of the electrification of this part of their system, having in mind the utilization of the water power available on the northern slopes of the Pyrenees. By 1914 four sections had been electrified with single phase current at 12,000 volts and 16.67 cycles, but all work was stopped at the outbreak of the war.

The French early in the war lost practically all their coal fields to the Germans. This more than anything emphasized the necessity of developing the water power resources of the country and electrifying the railroads wherever it could be economically done. Thus on the cessation of hostilities one of the first acts of the Government was to send a technical commission abroad to study existing railway systems.

The commission, after visiting Switzerland, Italy and America, recommended that 1,500 volts, direct current, be adopted as the standard for the electrification of all French railroads, and the Midi Railways Co., in conformity with this decision, immediately resumed the work interrupted by the war on this new basis. The sections already electrified at 12,000 volts will be changed to 1,500 volts direct current, so as to have a uniform system throughout.

The power will be generated in six stations or groups of stations capable of developing a total 362,000 HP., the stations being put up progressively as the different sections are electrified. The head of water varies from 350 ft. in the station with the lowest head to a maximum of 2,500 ft. Power is generated at 8,000 volts and 50 cycles, and is distributed to the railway substations over a 60,000 volt three-phase distribution system, distant points of the distribution system being connected by 150,000 volt transmission lines.

The railway sub-stations, which are located along the railroad at intervals of 12 to 18 miles, are connected directly to the 60,000-volt distribution system. They all contain rotary converters with the exception of a few in which mercury arc rectifiers will be used.

The equipment for the generator stations, the distribution system, the railway sub-stations and the locomotives will be built in France. The Westinghouse Electric & Manufacturing Co. of Pittsburgh, secured a contract comprising a large part of the 150,000-volt transmission system, including the transformers, synchronous phase-modifiers for the voltage control, and the relay protective gear.

For the initial development three generating stations will be utilized. The 150,000-volt lines will connect these with the distant cities of Pau, Dax and Bordeaux to the west and Toulouse to the east. At the generating stations 20,000 kv-a. banks made up of Westinghouse single phase two-winding transformers will raise the voltage from 60,000 to 150,000 volts. At the sub-stations near these cities the transmission system connects again with the distribution system through step-down transformer banks of 20,000 kv-a. made up of Westinghouse single phase three-winding transformers lowering the voltage from 150,000 to 60,000 volts. These transformers have a third winding of 6,600 volts for feeding Westinghouse synchronous phase modifiers.

These machines are intended to automatically keep constant the voltage at the sub-station irrespective of the load. Owing to the length of the lines and the high voltage of the transmission they are designed to cover a wide range of reactive kv-a. At Bordeaux, there will be two phase modifiers each of 15,000 kv-a. capacity and 7,500 kv-a. lagging capacity. At Dax and Toulouse there will be in each two machines of 8,000 kv-a. leading and 4,000 kv-a. lagging capacity. All these phase-modifiers are equipped with the Westinghouse patent automatic voltage regulator designed to cause the machine to give the right amount of reactive kv-a. leading or lagging required to keep the line voltage constant.

The Westinghouse Co., in conjunction with the engineers of the Midi Railways, worked out a complete scheme of relay protection embracing the generator, distribution and transmission. The generators and transformers are individually protected differentially; that is, they are automatically taken off the line in case of internal trouble.

The transmission and distribution are so laid out that the supply to the railway sub-station is assured. The lines are therefore for the most part in duplicate, except where sections are fed from both sides. Where the transmission lines are in duplicate they are equipped with balanced line protection by means of the recently developed Westinghouse directional relay which does not require potential transformers. The whole relay scheme is so laid out that in case of trouble in any section of line or piece of apparatus the part in trouble is isolated without interrupting the supply to the rest of the system.

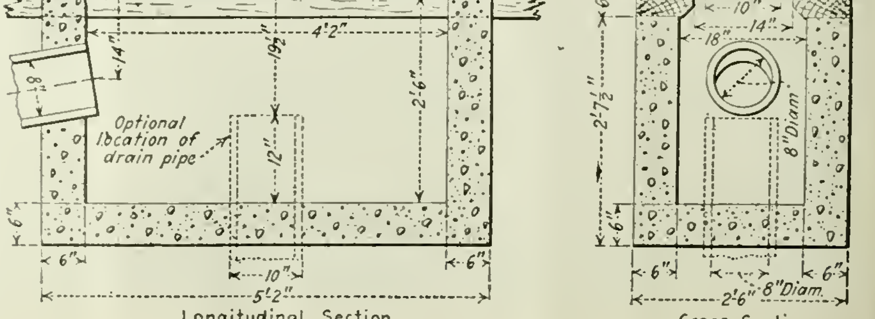
New Type of Track Drain

A new type of track drain now being tried out by the New York State Railways is described by Leon R. Brown, Office and Field Engineer of the company, in a recent issue of the Electric Railway Journal.

The principal features are the brick or concrete catch basin with a dirt chamber and the flat street surface with large openings. The drawing shows the details of the construction. The connections to the sewer consist of a 10-in. sewer pipe embedded in the brick or concrete walls of the catch basin. The pipe can come in from any direction or any angle, but it is always so arranged that the bottom of the opening will be 1 ft. above the bottom of the chamber.

To avoid wide spacing of ties, it was necessary to set the framework of the cover on top of the ties where it is held in place by lag screws or track spikes. The ties are dapped at each end to form a table to support the casting and thus make the use of shims on top of the ties unnecessary. The cast frame and cover are stock material made by the Barbour-Stockwell Co. for use with low T-rail, and this cover is used where the pavement is laid under the head of the T-rail. Other covers can be secured to fit any type of rail or pavement but the cover should always be flat, and the pavement should be sloped back for several feet on either side to meet the cover. This construction avoids bumps to vehicular traffic and leads all water into the proper drain.

This track drain costs only about one-half what the old standard cost, is easier to handle and install, will take more water from along the rail and is much less likely to become clogged both on the surface and under ground. The old standard drain consisted of a large funnel-shaped casting with no provision for trapping dirt, leaves, sticks, etc. The new catch basin can be cleaned with a shovel instead of having to be flushed.



Longitudinal Section

Cross Section

Vertical Cross and Longitudinal Sections of Drain.

Progress of Drill Steel Investigation.—In the course of the drill steel investigation being conducted by the U. S. Bureau of Mines and the Bureau of Standards in co-operation, a preliminary survey is to be made by F. B. Foley, metallurgist, and an assistant to be appointed later, to determine the causes of breakage of steel used in oil stills and in the drilling of oil wells. A study will be made also of the use of steel in the Missouri-Kansas-Oklahoma lead and zinc district and in the southeast Missouri lead belt. Recommendations will shortly be submitted to Dorsey A. Lyon, Chief Metallurgist of the Bureau of Mines, covering the co-operative work on drill steel for the remainder of the present fiscal year. A report of work done on the drill steel survey will be submitted in the near future.

Method and Cost of Cleaning Track with Power Driven Sweeper

One of the latest forms of mechanical labor saving equipment for maintenance of way work is a power-driven track sweeper now in use on the Central region of the Pennsylvania R. R. This unit sweeps up and loads into cars the dirt, chiefly ashes, cinders and coal dust, which fouls the track and ballast with extreme rapidity in the heavy traffic, mountain sections of the road where pusher locomotives are used regularly. An average speed of about four miles an hour is maintained and the track is well cleaned. Tests indicate that the cost is approximately one-half of what it normally would be with hand labor. We are indebted to the Railway Age for the following particulars of this new equipment.

The sweeper unit is used chiefly on the pusher grades of the Pennsylvania main line through the Allegheny mountains, i. e., on the westbond tracks from Altoona, Pa., to Gallitzin and on the eastbound tracks from Johnstown, Pa., to Gallitzin. In some instances, sidings and yard sections are also cleaned by this equipment. The dirt accumulates very quickly on this part of the line, there being about 102 miles of track which require cleaning from four to six times annually. This is necessary primarily to keep the signals working properly as well as to keep the track in such condition that a proper inspection of the rail fastenings can be made periodically and that the ballast does not become badly fouled with consequent interference with good drainage.

The sweeper consists fundamentally of a rotary steel broom 3 ft. in diameter and 7 ft. long built up from steel splints measuring 1/32 in. by 3/16 in. in cross-section. This broom is suspended beneath the frame of an old flat car by special hangers which permit it to be raised or lowered at will. This is accomplished through the use of an air brake cylinder connected with the train air line. The broom turns at about 100 r.p.m., and is chain driven from a gasoline engine mounted on the car deck. A steel pan hinged and shaped to fall over the two rails is attached slightly ahead of the rotary broom which sweeps the accumulations up this pan onto a conveyor belt 7 ft. wide. This belt operates over two rollers spaced 8 ft. 9 in. center to center and is chain driven. The dirt and ashes are retained on it by 2-in. angles riveted to the belt across the full width of the belt and spaced 1 ft. 8 in. apart.

The debris which has been elevated by this belt is discharged into a hopper which in turn discharges it upon another conveyor belt mounted in an extension boom and running over rollers 24 ft. 2 in. center to center. This permits the final discharge of the accumulations at a convenient distance from one end of a hopper gondola or other type of open top car which is coupled next to the sweeper. The entire arrangement is housed over for protection from the weather and to secure maximum results in operation. The sweeper unit and car is handled by a locomotive, which can be one of the lightest engines in service as little power is required. The work is generally carried on under traffic and the best results are obtained with the device after a light rain has fallen.

When the unit was constructed an obsolete flat car was procured which was somewhat narrower than the more modern cars. This limited the length of the broom to 7 ft. The unit is thus able to sweep out towards the end of the tie for only about 6 to 8 in. from the rail. It does, however, do good work, removing deep accumulations easily and thoroughly.

The experience to date after about 50 miles of sweeping has shown that the broom wears but little, there having been only about 1½ in. wear for that amount of sweeping. Heavier splints are being considered, however, not only with the idea of decreasing the wear but to secure a greater depth of cleaning between the ties. Another change contemplated involves the use of shallow buckets in a staggered arrangement on the main conveyor belt instead of the present angles. The broom itself picks up practically everything which may be on the track. Ordinarily about one car of dirt is secured per mile of track swept and this is picked up at a comparatively low cost. A recent test made on a badly fouled section of track where the dirt was mixed with engine sand and well compacted, to determine the costs involved produced the following results:

Cost When Using Sweeper.

Engine service (including engine and train crews' time, fuel, oil, engine house expense and water), 8 hours at $5.79	$46.32
Sweeper operator—8 hours at $0.535	4.28
Laborers, three—8 hours—24 hours at $0.40	9.60
Gasoline—9 gal. at $0.29	2.61
Motor oil—1 gal. at $0.72	.72
Total	$63.53
3.828 ft. of track cleaned and dirt disposed of, cost per lin. ft.	$0.0167

Cost for Manual Labor.

One foreman—9 hours at $6.28	$ 5.62
14 laborers—9 hours, 126 hours at $0.40	50.40
Total	$56.05
1,650 ft. of track cleaned and dirt disposed of, cost for lin. ft.	$0.034

The new sweeper has been developed in the maintenance of way department of the Central region; W. D. Wiggins, chief engineer maintenance of way, and R. Faries, division engineer. The sweeper was designed and constructed by George Ehrenfeld, supervisor of track.

Rapid Relaying of Track Under Traffic

Lieutenant S. W. Gould, Corps of Engineers, student-observer with the New York Division of the Pennsylvania R. R. reports in the September-October issue of The Military Engineer the replacing of 2,800 ft. of 100 lb. rail by 130 lb. rail in 35 minutes. This is not claimed as a record, but is cited as an example of the ingenuity that track supervisors have developed in meeting the problems incident to maintenance and replacement under dense traffic conditions.

The work was done at New Brunswick, N. J., on the 4-track Pennsylvania Line, where passenger trains run about 10 minutes apart and freight trains about 30 apart on each track. The time (35 minutes) did not, of course, include the preliminary work. This consisted in placing the new rail in position close to and parallel with the old rail, bolting it together and attaching the signal circuit bonds; pulling as many outside spikes as could be spared from the old rail and lifting slightly one inside spike on each tie (these inside spikes give alignment and gauge for the new rail); removing alternate tie plates and adzing the ties for the new plates. All of this required about 70 men for one day.

At 10:15 the train dispatcher phoned that 45 minutes was available for the work. With the breaking of the rail at one end the signal circuit was broken and the automatic signal came to the "stop" position; a flagman was sent out as an added protection. The first gang, equipped with goosenecks, pulled the remaining outside spikes; the second gang moved the old rail out of the way with lining bars; the third gang moved the new rail into place against the raised inside spikes, and the fourth and last gang spiked it down. When the new rail was in place the first three gangs started back, driving spikes. The track was cleared for traffic at 10:45, 10 minutes ahead of the time limit.

The premium on sound organization is high, as a tie-up of the line, even for a few minutes, would be very expensive.

After traffic was resumed, the remaining tie plates were replaced, the ties spaced, track aligned, gauged and surfaced, spiking made solid, bolts tightened, anti-crawling devices attached and ties brought under rail joints.

How Watches Are Tested for Canadian Surveyors

All watches used by Dominion land surveyors are now tested by the watch testing section at the Surveys Laboratory of the Topographical Surveys Branch of the Department of Interior of Canada, when new or after being repaired. The result has been to improve considerably the standard of the time-keepers used, with consequent increase in the accuracy of the work. At the Surveys Laboratory the working standard is a precise clock, checked daily by signals from the Dominion Observatory. Timekeepers are electrically compared with this clock. Watches are tested to determine the variation in rate between five different positions and at various temperatures. They are also tested for regularity of rate as the spring runs down. Special tests are provided for extra high grade watches and chronometers. A limit of 3.5 seconds per day is allowed for the mean variation of rate between the different postions and 5.0 seconds per day between rates at the three temperatures of test. There are other allowances for various characteristics, and at no time during the test must a watch be in error by more than 10 seconds per day to receive a certificate. Even to attain the standards mentioned above, watches must be very carefully adjusted. It was found that, as a rule, of even the high grade watches tested, more than 50 per cent failed. Experience has shown that the cost of a watch is not necessarily a criterion for its performance under test.

Roller Bearings for Railway Cars.—A successful roller bearing for use in the construction of railway cars has been devised, according to Sir Henry Thornton, manager of the Great Eastern Railways of England. According to him the development has been made possible by the great improvements in steel manufacture made since the war. A particularly hard but not brittle steel is used, which can stand a strain of 21 tons. One man can easily move a 27-ton coach equipped with these bearings.

Rehabilitation of Street Railway Tracks

Conditions Under Which the Work Was Carried Out and Methods Employed Described in Paper Presented Sept. 20 Before Boston Society of Civil Engineers

By F. B. WALKER,
Chief Engineer Eastern Massachusetts
Street Railway Co.

It is obvious that if tracks are properly maintained, rehabilitation will not be necessary.

The tracks of the old Bay State system prior to its reorganization June 1, 1919, had not been properly maintained and it became necessary to begin a very heavy program of rehabilitation when the Public Trustees took charge of the property of what then became the Eastern Massachusetts Street Railway Co.

Our system covers the eastern section of Massachusetts, from the Merrimack Valley on the north to Fall River to the south, but with very little mileage in Boston proper. We operate about 700 miles of which half are unpaved country lines and half are paved city lines. Our country lines are constructed for the most part alongside of town roads and state highways and when the work started three years ago, they were in a deplorable condition to say the least. They were low and badly drained, the ties were bad, rails out of line, surface and gage and the joints were low, battered and pounding. We have now completed the overhauling or reconstructing of about 200 miles which, together with about 50 miles which were in good condition, gives us 250 miles of very good country track and leaves less than 100 miles to fix up in 1923 when we plan to complete our program.

At the start it was thought necessary to relay the major portion of the mileage of country track with new rail, but with the methods gradually developed, we have been able to save many miles of light rail formerly thought worn out. This was done by various methods, such as surface benders, joint welding, surface welding and grinding.

Our city paved tracks were very bad, although not so bad as the country tracks, but bad enough. In cities, street railway engineers are faced with very difficult and expensive problems due to the requirements of street pavements. Country lines were laid with T-rails, 48 lb. to 75 lb. per yard and paved tracks 90 lb. to 140 lb.=7 in. to 9 in. high, buried in macadam, concrete or granite block pavements. Maintenance and renewals are expensive and reconstruction much more so: yet we have entirely reconstructed 40 miles and have made very substantial repairs to many more miles as well as to completely renew 700 pieces of special work, such as curves, frogs, switches and mates. On both classes of tracks, we have installed very nearly 400,000 ties,—overhauled, rebuilt or repaired about 300 miles,—repaired the joints on about 260 miles,—ground the surface of 75,000 joints and ground the corrugations from the tops of about 120,000 lin. ft. of girder rails in paved streets. We are planning on completing the rehabilitation of the system in 1923,—at least to the point where normal maintenance only is necessary.

Someone has said that the street railways of New England constitute its drainage system. Some of our old tracks seemed to prove this. They were usually well below the highway, completely backfilled and had no good system of drains. During spring thaws and rainy days many miles were completely submerged. Some of our city tracks were as bad. One winter we lost by burned out motors alone, the sum of $600,000.

Improvement of Track Drainage.—Our method of improving this situation was to raise the tracks out of the mud, put in 6 in. to 18 in. of good gravel ballast, clean off the backfill above the ties by making full open section where we could, or half open in other places and to dig deep side ditches and off-take ditches. In this work we were assisted very materially by the co-operation of city, town and state highway engineers when they realized our purpose and saw the results, and the results have been remarkable. The drainage of city tracks was accomplished largely by the raising of tracks and the placing of more track catch basins.

The matter of better ties was given considerable thought and we have adopted a good tie for street railway, using on country lines a chestnut tie untreated, 6 in. by 8 in. by 8 ft., although some of these have a face of 6 in. when hewed ties are used. Our paved tracks are retied with 6 in. by 8 in. by 8 ft. yellow pine treated with 10 lb. of creosote oil. Chestnut ties in open tracks have a life of 12 to 15 years and in paved track 18 to 22 years. With treated pine ties we hope to have a life of 25 to 30 years.

Ballasting Country Tracks.—We are ballasting country tracks with at least 6 in. of good, clean gravel and our city paved tracks with at least 6 in. of broken stone, rolling the sub-grade and also rolling the stone ballast before laying the track. Our best country lines are laid with 75 lb. A. S. C. E. Tee rail with welded joints and our paved tracks with 7 in. Tee, 91 lb. or 9 in. Girder, 104 lb.—the 7 in. Tee being our standard and is used wherever the depth of paving will permit,—tie plates being used on all paved tracks.

Welding Joints.—All tracks both country and city, overhauled or rebuilt, have all joints welded and ground, and to me, the process of proper treatment of joints is the most interesting. We have used several very satisfactory methods of welding joints. The Lorain Bar which is spot welded by an electric current. The Thermit which is a chemical reaction designed to fuse the rail ends together, and the so-called seam weld by using either the carbon arc or the metallic arc to place a metal bead along the top and bottom of plates at the rail ends.

All of these methods are good if properly applied. None of them are perfect, but we have for the past two seasons employed the metallic electrode arc method most successfully and believe it for the moment, to be the best for our work. So far we have never found a failure. True, we have had plates break, also rails break, but these types of breaks do not total 2 per cent of the total joints welded and are probably due to temperature stresses or defective rail or plates. Expansion joints are put in about 750 ft. apart on open tracks, but no expansion joints are needed or ever put in on paved track, as it can be readily shown that if rail is held in line by pavement, temperature changes produce stresses which are well below the elastic limit of the rail.

Method of Repairing Joint.—In repairing a joint on old rail, we first repair or renew the ties, then clean the plates of scale and rust, replace them with bolts or a clamp, bend the rail slightly above the proper surfaces with a sturdy rail bender of our own design, retamp the ties, weld on the plates, surface weld the cup if there is any in the rail and then ground the surface to a perfectly level plane with either a rotary grinder or a reciprocating grinder. The result is a solid, smooth riding joint and one which should require very little maintenance.

New rail is welded the same way, except no vertical bender or surface welding is needed. All joints of new rail are ground to remove all irregularities at the joint due to mill rolling tolerances. We are doing very little bonding at rail joints as the welding serves to carry the negative current return satisfactorily. The electrical resistance being no more and usually less than the equivalent amount of rail. A recent bond test of 450 metallic arc welded joints a year old indicated 449 of them perfect electrically and one a trifle high. This is considered more nearly perfect than we had ever hoped for.

Welders and Grinders.—Our seam welders are of the dynamotor or motor generator type, of a reversed polarity, using 20 volts and about 150 amperes. Our surface welders are of the resistance type of much less electrical efficiency due to the high resistance. They are direct polarity. Of grinding machines, we use two general types. The rotary type, using a 14 in. emery driven by a 5 H. P. motor. We operate about 30 of these. Also the reciprocating type which is essentially 4 carborundum bricks moved back and forth over the rail by a 5 H. P. motor through a crank and eccentric action. We have 10 of these and they are used for grinding corrugations from the heads of rails and on surfaces of joints of new rail. The rotary machines will grind 15 to 30 joints per day and the reciprocating machines 200 to 400 ft. of corrugated rail,—all depending on traffic conditions and amount and depth of corrugation, as well as hardness of the rail.

I have great hopes that metallic arc welding will be used more in structural work. I have already used it in some bridge repairs as for instance, repairing a damaged I-Bar on the Merrimack River, Lowell. We also assisted the Bridges and Ferries Division in repairing a broken 6 in. turning shaft of the North Chelsea Draw by Thermit welding it. This shaft broke again the other day, but not through the weld.

Winter School for Track Men.—Our tracks are still far from 100 per cent condition, but we hope to see near 70 per cent condition in 1923. Better work must be done on street railway tracks than ever before. It is not a solution of large engineering problems or the spending of large sums, but it does mean close attention to details and building up of proper morale of the men and a further training of men in the best way of doing work. We are so confident that the best work can be done only by men properly trained, that we conducted a Winter Track School during last December, January and February in which we attempted to train 125 of our engineers, roadmasters and foremen. Illustrated lectures each morning of the week were followed each afternoon by shop work and the results obtained this year by instructing these men amply repaid our efforts in conducting the school.

Effect of Improved Tracks on Cars.—It will be noticed that in my discussion of the rehabilitation of tracks, I have made no particular reference to the effect on the cars which operate on our tracks. There has been a marked change in the weight and character of rolling stock in use on street railways during the past few years.

On our own lines, when the old horse cars were remodeled for electric traction, the companies were using cars with weight approximately 7 tons. Many of these were the old horse cars with motors on them, but as a general rule, most of the early equipment was very light. First they had 4 wheels, and later, as the weight and length of cars increased, double cars of 8 wheels were used. Weight gradually increased from the early nineties to about 1918 when they were operating cars 22 to 25 tons.

The equipment on our property was getting in very bad shape, not only to lack of maintenance of the equipment, but due to the constant jarring and pounding which the cars received as they passed over bad joints. During the last few years, street railway companies, particularly our own, have started to use a very much lighter equipment, and the so-called Burney safety car of which we have several hundred, weighs 8 tons. These have 4 wheels spaced 8 ft. between axles.

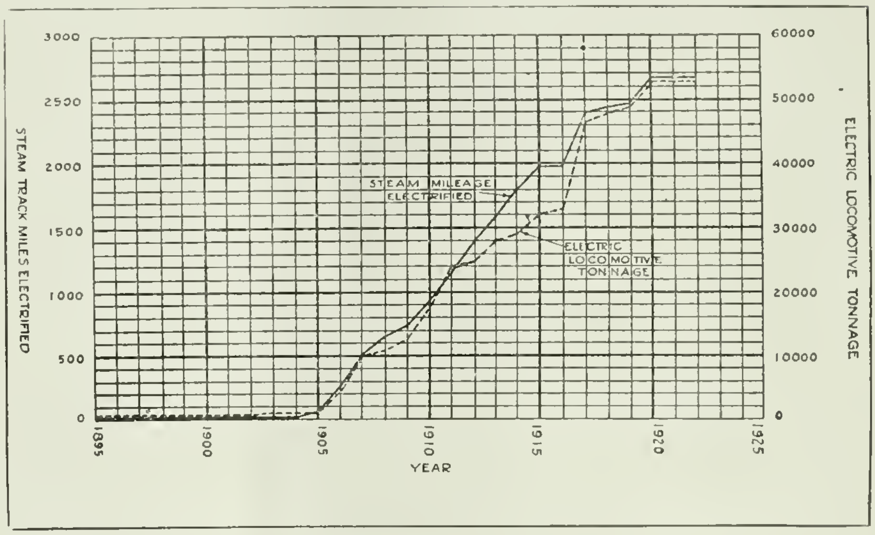
Recently, a few cars with 8 wheels have been purchased which weigh 13 tons.

We are already noticing considerably decreased maintenance costs in our track due to the fact that more light weight cars are being operated. We are also experiencing a very decided decreased maintenance cost in the rolling stock department, amounting at least to $100 per car per year, due to the work of rehabilitation which we have carried out in the past three years on our track system, so that we are not only receiving a very substantial benefit in reduced maintenance cost of track, but we are also receiving a large benefit from reduced maintenance cost of equipment and other benefits to increase comfort of car riders and people who live along the lines.

Civil Service Examinations for Engineering Positions.—The U. S. Civil Service Commission, Washington, D. C., has announced the following open competitive examinations: Mechanical engineer to be in charge of design construction and repair of precision instruments for coast and Geodetic Survey; $3,000; applications close Nov. 7. Laboratory assistants senior grade, in Bureau of Standards; $1,200 to $1,380; Nov. 8-9. Junior engineer and deck officer, U. S. Coast and Geodetic Survey; $2,000; Dec. 13 and 14. Structural steel work draftsmen, $6.80 to $7.20 per day; Dec. 29.

Mileage of Electrified Steam Railroad and Electric Locomotive Tonnage

The accompanying chart reproduced from the report of the Committee on Heavy Electric Traction presented Oct. 2 at the annual convention of the American Electric Railway Engineering Association shows the growth of steam railroad mileage electrified and electric locomotive tonnage in heavy traction service in the United States and Canada. Practically no additions to the mileage have been made during the past year. The committee states, however, that many railroads are actively considering the problem of electrifying and it is probable that during the coming years there will be important decisions in connection with electrification and considerable work probably will be started soon.



Growth of Steam Railroad Electrified and Electric Locomotive Tonnage In U. S. and Canada.

Use of Treated Cross Ties By American Railways

According to statistics on timber preservation in the United States in 1921, proposed by the U. S. Forest Products Laboratory in co-operation with the American Wood Preservers' Association about 50 per cent of the cross ties now purchased by the railroads of this country are subjected to preservative treatment before being inserted in track.

The number of crossties treated in 1921 was 55,383,515 ties as compared maximum record. Of the total number of crossties treated during 1921, 35,819,931 were hewed and 19,563,584 were sawed. The crossties treated in the largest quantity were yellow pine, the total number reported being 21,511,719. Oak ties ranked second with 12,838,157 and Douglas fir ties were third with 4,960,115. Other ties treated in any quantity were western pine, beech, gum, tamarack, maple, birch, elm and hemlock.

A total of 22,046,466 crossties were treated with creosote in 1921 and 30,265,947 with zinc chloride. The number of ties impregnated with the zinc-creosote emulsion was 3,061,234, while 9,868 were subjected to treatment with miscellaneous preservatives.

In treating ties with creosote an average absorption of 7.21 lb. per cu. ft. was obtained. Where zinc chloride was used the average quantity of preservative that was forced into the wood was 0.48 lb. per cu. ft. With the use of the zinc-creosote emulsion the injection amounted to 0.49 lb. of zinc and 2.75 lb. of creosote. Practically all of the wood-preserving processes used commercially were employed in the treatment of crossties.

Electric Operating Data on American Railroads

Interesting information on the operation of some of the principal electrified steam lines in this country is given in the following table, taken from the report of the Committee on Heavy Electric Traction, which was submitted Oct. 2, at the annual convention of the American Electric Railway Engineering Association.

OPERATING DATA FOR ELECTRIFIED SECTIONS OF AMERICAN RAILROADS.

Name of Road	Mileage of road	Mileage of single track	Total Kw-hr. per year	Number of locomotives			Aggregate wt. of locos. pass frt. switch.	Multiple unit cars		Gross ton miles per year (trailing)		Locomotive miles per year	
				Pass.	Frt	Switch.		No.	Av. wt	Passenger	Freight	Passenger	Freight
							Tons		Tons				
Baltimore & Ohio R. R	3 6	7 96	5,628,690	4	4	0	720	0				†232,756	
Boston & Maine R. R	7 92	23 80	7,230,640	†17	..		916	0		18,424,000	158,053,000	36,440	113,502
Butte, Anaconda & Pacific	28 00	90 50	18,740,189	2	26		2,240	0		13,659,260	200,149,124	83,524	604,280
Chicago, Milwaukee & St Paul	646 70	860 40	‡160,932,232	15	42	5	16,519	0		599,516,000	2,901,500,000	920,568	1,900,564
Erie R. R	34 00	40 00	2,042,843					8	52	24,641,408			
Grand Trunk Ry	4 00	12 00	1,103,470	†16			796	0		4,260,156	35,507,215	10,746	180,594
Great Northern R. R	4 70	6 50	3,003,700	†14			460	0		3,800,000	8,411,067	26,424	46,330
Long Island R. R	*85 09	227 09	103,450,000	0	1	0	90	634	46	1,073,385,277			27,499
Michigan Central R. R	4 60	26 40	8,246,560	†10			1,080	0		14,067,000	60,408,000	48,525	243,907
New York Central	53 60	261 89		73			8,669	256	57	1,216,756,000	3,901,000	1,306,417	893,511
New York, New Haven & Hartford	*87 56	530 58	‡130,059,200	52	38	16	11,652	79	63	‡1,254,674,063	1,123,624,301	‡3,331,068	894,734
New York West & Boston	23 [illegible]	73 41	11,422,794			1	89	45	60	97,917,360			11,274
Norfolk & Western	35	108 26	50,503,430	0	12	0	3,600	0				21,138	330,536
Pennsylvania R. R.:													
New York Terminal	13 4[illegible]	100 18	59,749,184	33		1	5,281	8	55	‡595,438,537		1,402,994	592,496
West Jersey & Seashore	[illegible]	150 38	15,339,680					107	49	261,496,377			
Paoli & Chestnut Hill	30 00	117 40	23,653,205		1		258	115	59	171,835,943			
Southern Pacific R. R.													
O. A. & B. Line	[illegible]	101 80						121	55	225,635,560			
Portland Line	140 32	141 70						49	51	100,148,000			

* Not including trackage rights [illegible] New York
† Total passenger and freight [illegible]
‡ Includes D [illegible]
§ Includes weight of locomotive.
¶ Partial electric operation on part of zone

Methods of Renewing Ties

Some useful suggestions on tie renewals are given by F. J. Meyer, assistant engineer, New York, Ontario & Western R. R., in the Cross Tie Bulletin, from which we quote the following:

Probably the ideal condition in tie renewals would prevail if a 100 per cent track man could go into the woods, select a perfect white oak butt, season it, treat it with creosote and put it in the track, being careful that his line, gage and surface were right before he did it. Unfortunately this is impossible, so the solution seems to be not to remove any tie unless it should be removed, for fear one may put a poorer tie in its place. This practice automatically leads to spot tie removals, which today are generally accepted as the most economical method. Of course, this method presupposes that a reasonably high standard of maintenance exists.

With this method the first proposition is the selection of the ties which are to be removed and their location, so that the new ties can be unloaded with proper thought for the work the ties must perform. The large oaks, for instance, should be unloaded for use on curves, while the softer ties can be economically used on light tracks and tangents. This distribution will probably take place some time before tie renewals actually begin, and in making the distribution care should be used to pile the ties so that they do not have to be trucked a great distance or np hill if the section is on a grade.

It is important that the entire section he picked up and lined before actually starting the renewals. This work, properly done, contributes very largely to the final success of the tie renewals program, because when actual tie renewals are started the men are less likely to be called to fix up rough track elsewhere and also because, in making spot tie renewals, there is then no good excuse for making the track rough as is so often done. Wide gage should be corrected, and where the rail has rolled out it should be rolled back so that it has the proper position. This must be done before the new ties are put in, else these ties will be ruined quickly, and it will be necessary to adze the new ties as much as the old.

It seems that tie renewals can be best made under ordinary traffic with the men working in pairs, after the ties have been actually laid on the ground preparatory to renewing. A very satisfactory way is to provide each pair of men with two shovels, one pick, one maul, a pair of tie tongs and a claw bar with the opposite end shaped into a pinch bar. The spikes are drawn entirely from the tie which is to be removed and started on three ties on each side of the one which is to be removed. The ballast is loosened on each side of the tie to be removed. The pinch bar is placed under the rail and the rail raised enough to slip a spike or wedge between the tie next to the one which is to be removed and the rail. The bad tie is then pulled out and the old bed prepared to receive the new tie, care being taken not to dig deeper than necessary. The new tie is then pulled in place. The next operation depends on the kind of ballast. If in stone or screened gravel it is better to let the rail down on the tie before tamping, while in cinders and unscreened gravel it is better to tamp the tie so that it is a little stiff. Of course, great care must be used in this, because when the engines do the tamping good judgment is necessary or the new tie will be a trifle stiff. The new tie is now spiked, the spikes in the adjoining tie tapped down and the ballast dressed. The two men then move to the next tie.

With this method two men will renew about two ties an hour, under average conditions, and a section gang of men, with a moderate distance to truck, will truck out 50 ties, renew them and pile the old ties in eight hours. These figures vary, of course, on different parts of one road, while some gangs will do almost as well in stone as others in cinders. The advantage of this method lies in the fact that the roadbed is not disturbed much.

The method also distributes the men so that they have more freedom of action. It gives an opportunity to pair them off so that each outfit will try to at least hold its own. As no jacks are used, the work can be carried on, as a rule, without flag protection. The greatest disadvantage seems to be the danger of running over the rails with the spikes between the ties and the rails. This happens very seldom and can be avoided entirely with ordinary care. One of the objections to the use of the jack in tie renewals is the distribing of the roadbed due to jacking the ties and rail out of place. A tie will come out easier if the rail is jacked high, but with hard ballast it is not likely to go back as it should. Of course, there is also the danger of jacking the track out of line.

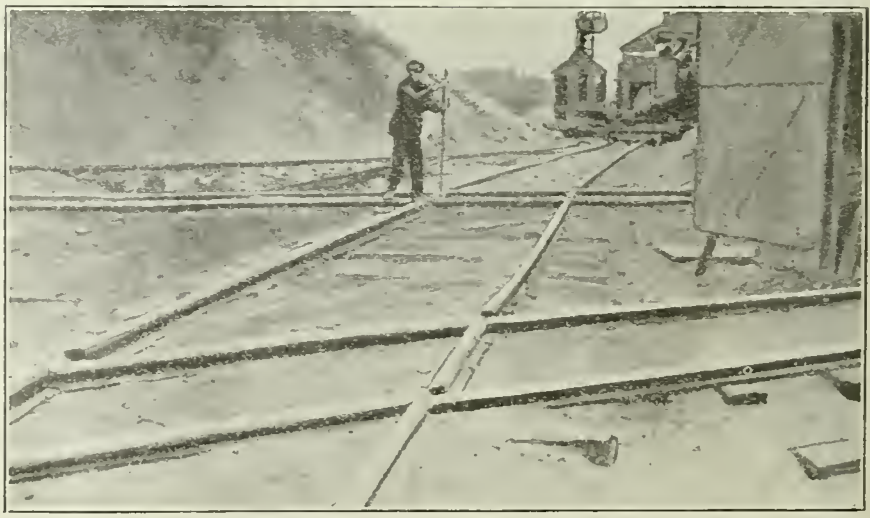
When track is being raised out of place and tie renewals are being made it is better to pull the spikes from the ties which are to be removed and the new ones put in while the track is jacked up than it is to dig them in before the raising. This also gives the foreman a chance to see just what condition his ties are in. If it is desirable to restrict the tie renewals closely when track is being raised out of face, no spikes should be drawn and the renewals should be limited to only such ties as will not be held np to the rail by the spikes. This insures economical renewals and safe track for a period of at least one year, for it is safe to say that the average tie that will hang to the spike is good for some service.

Saving the Cost of Frogs in Crossing Tracks at Sand Pit

A simple method of making track intersections is in use at the pit of the J. E. Carroll Sand Co., near Atica, N. Y. The arangement is described in Rock Products.

Two locomotive cranes are used for digging the sand and gravel, and to get from some parts of the pit to the coaling station, and from one end of the pit to the other, necessitates some crossing tracks. A common method of making such track intersections is to install frogs, but where one or the other tracks of the intersection has to be moved occasionally this means much trouble in moving the frogs.

In this pit no frogs are used for the standard gage tracks over which the locomotive cranes operate. Instead, the tracks in one direction are laid straight through, and the cross rails are cut and laid so they touch the outside of the rails and project an inch or so above the main rails. These do not interfere with traffic in the main direction, and when it is desired to move a locomotive crane in the cross direction two pieces of rail cut to fit just inside the main rails, and in line with the cross rails, are spiked into place in a minute or two and provide a safe crossing. These inside pieces are also an inch or two above the main rails, and these elevations permit the wheel flanges to pass over the main rails without injuring them and without the wheels jumping the tracks.



Track Intersections at Pit of J. E. Carroll Sand Co.

Only six spikes are needed in each rail, and these can be lightly replaced in the old holes each time. The time required to lay the rails and to take them up again is not more than three or four minutes. The illustration shows a man pulling the spikes after a crane has passed over two successive crossings of this sort.

Examination for Inspectors of Construction.—U. S. Civil Service Commission, Washington, D. C., announces a civil service examination for inspector of construction at $7.20 per day.

Co-operation Between Engineer and Contractor

Abstract of An Address Presented Sept. 13 Before Los Angeles Section, American Society of Civil Engineers

By ARTHUR S. BENT.
President of the Associated General Contractors of America.

The contact between the engineer and contractor should always be one of mutual confidence and co-operation but this is made difficult under common form of contract which at once sets up an abnormal relationship. Their interests do not run altogether parallel. There is a fertile field for mutual irritation and distrust.

The contractor, while we may safely credit him with a desire to do a good job, is primarily in the business to make money and he can't help viewing the acts and attitude of the engineer in the light of their effect on his profits. The engineer is chiefly concerned with the satisfaction and credit he will get from a first-class piece of work. Usually he is generous enough to hope the contractor will make money, but of course he feels no responsibility about this.

In the contractor's heart, born of his experience, there is always the feeling that he will be made the "goat" in many little ways, perhaps in big ones, and that he is pretty sure to suffer some injustices on every contract. In the engineer's heart, on the other hand, is the fear that if the contractor isn't watched he may "scamp" the job, or at least, neglect it. Such a mental attitude as this is obviously a brake on progress and a heavy handicap to the thing we both are trying to do.

The Form of Contract to Blame.—I firmly believe that the origin and foundation of this attitude is the form of contact under which we ordinarily work. In its development one party to it has no voice. It is drawn up for the owner. In every line it breathes distrust of the other party. It is full of drastic provisions which indicate complete lack of confidence in the contractor.

Did you ever happen to see a contract drawn entirely by the contractor's attorney? I can assure you it makes an interesting document and one that you would never allow your client to sign, yet it only ties up the owner and his engineer exactly as you tie us. Our bankers are always saying to us, "Why did you sign such a contract?" Our attorneys are always asking, "Why didn't you bring that to us before you signed it instead of after you got into trouble?" The answer is obvious. The contractor must contract. He must take what he can get or go out of business. That is his answer, but there is no answer from or for the owner. And I go further and say there is no answer for the engineer if he asks us to make a contract which he himself would not sign and bond.

"Caveat Emptor" Must Go.—It is true that the unfair contract is seldom written by the engineer. It is the ingenious deviltry of the owner's attorney, whose sole function is a conscientious and cold-blooded effort to secure every possible advantage for his client. Whatever its source, it is out of joint with the spirit of business today. "Caveat emptor" is now a business barbarism. Today we say, "Live and help live."

The Universal Contract.—So, if you think with me that the unfair contract is probably the most serious stumbling block in the way of complete co-operation between us, you will welcome the better day that is at hand through the efforts of the Associated General Contractors of America. For more than a year committees from your organization, the Associated General Contractors, the American Institute of Architects, the Railway Engineers Association and the Highway Engineers have been working together earnestly to develop a fair type of universal contract, which when completed, it is hoped, will receive the formal sanction of these bodies and be officially adopted by them. These contracts will cover the fundamentals of the four great divisions of construction—railways, highways, buildings and public works, and it will only be necessary to make them fit local conditions and specifications in each case. Two of these, the building and railways contracts, have already been practically worked out. The ones you are more particularly interested in will no doubt be ready soon; and it is our hope that they will look good to you and have your support toward their adoption by the American Society of Civil Engineers. With the official adoption of these contract forms, I firmly believe that three-fourths of the litigation and half of the friction will disappear.

Engineer's Suggestions Appreciated.—In spite of some unfortunate aspects of our contracts, and the disagreements that arise under present systems, able and conscientious engineers have the complete confidence and respect of the contractors. We admire in you the qualities which we know are necessary for success in our own many-sided business—courage, self-sacrifice, patience, persistence and vision. We pay unconscious tribute to the knowledge you have acquired, which passeth even our understanding. We are proud of your friendship when we win it, and like true friends we deplore your one and only class weakness—professional jealousy. We admire your orderly, exact, complete way of doing things, and we try to make our own operations as systematic. We know very well that you can come on to our jobs and see the lost motion, detect the clumsy methods, and tell us where and why we are not making good and we value highly your constructive criticisms and suggestions. We learn much from you.

Proud to Be Just Contractors.—We are proud, nowadays, to be just contractors, for a new day has dawned on our great industry. One writer's version of the successful contractor is this:

"He must have sufficient imagination to be able to visualize his work completed when it has just started and to bend all things to that end. He must have a sense of humor, so that he may see the funny side of the people he has to deal with, thereby saving himself from nervous prostration; sentiment, to appreciate the dramas and tragedies which daily occur before his eyes; courage, to show the way where there are no battle flags flying or war correspondents to relate his exploits, and to take his medicine in silence when things go wrong; the tact and wisdom and energy of a good executive, and—last but not least—honor, to inspire him to deliver a square deal, when he might easily profit unfairly with no one the wiser."

Society Needs the Contractor.—We contractors believe that our craft is the orderly development of a legitimate function. We are convinced that desirable economic conditions flow from this set up. Society needs the contractor, the man who builds up a great fabric of experience and skill and organization and appliances and holds them ready for responsible public service. The general contractor is needed as a standing army is needed. Doubtless, with a Government treasury behind us we can, at great expense, recruit, drill and equip armies and at whatever cost of life and treasure win wars with them, but no nation would accept this method as its main reliance for war if it were sure of constant wars.

Day Labor Versus Contract.—If this is true, then your position is unsound when you recommend or undertake construction work with your own forces, particularly public work of importance. If this is right, it is right all the time, and a final analysis finds the Associated General Contractors and the entire construction army, built up by an endless process of specialization and elimination, swept into the discard. Don't you think this would be a disaster to society? Private construction would then inevitably be the victim of hopeless incompetence, now eliminated by the fierce fire of competition. Public work would become the plaything of politics. This is so generally recognized that the people will not vote for great improvement bond issues if they know in advance that their expenditure will be handled by public officials without competition.

Day Labor Costs More.—Let me recall the startling contrast between the results of contract work and day labor work by the State's forces in the construction of the California highways. In the joint report of the two great automobile clubs of California you will find the statement that, of 300 contracts done by the State by day labor amounting to seven millions of dollars, the State's accounts showed unit costs on only five. (How long do you think a contractor would last if he did business that way?) On two of these five the State first called for bids, rejecting them on the recommendation of the engineer, who then went ahead with the work by the State's forces. One of these was in Los Angeles County and the other in Contra Costa County, and the record shows the following figures with the unit prices:

	Estimate.	Bid.	Cost.
1 ...	$102,000.00	$117,000.00	$160,000.00
2 ...	43,000.00	64,000.00	81,000.00
Excavating	0.55	1.10	1.17 per cu. ft.
Concrete	4.50	7.50	10.38 per cu. yd.

In the "Study of California Highways," by the United States Bureau of Public Roads, in an analysis of 20 jobs, 10 of which were done by contract and 10 by the State's forces, the contracted jobs exceeded the engineers' estimate 39 per cent., while the State day labor jobs exceeded the engineer's estimate by 193 per cent. Comment on such a showing as this seems superfluous, except to say that it is absolutely typical and could be multiplied indefinitely.

Day of Contractors' Combinations Is Over.—What arguments are there for not letting work out by contract? The common one is that the contractors' profit may by combinations be made too high. I want to assure you that general contracting has passed out of the era of combinations, and it is today absolutely impossible to "frame up" an important piece of work. If bidding is genuine competition, is it to be assumed that all of these great construction oragnizations, carrying their loads of overhead whether working or not, are willing to let these jobs go by unless they can make exorbitant profits? As a matter of fact we cut our costs as low as we dare go, in the hope of landing jobs, and then add from 10 to 15 per cent.

Do you feel as engineers, that there is any obligation on you, or that it is worth your while, to gamble in an effort to save part of that per cent.; and are you justified in believing that, in spite of his lifetime of struggle in the game, you can beat the contractor's costs? You cannot know that bids will be too high until you get them, and you do know how often the opening of bids reveals a gratifying reduction of the engineer's estimate.

A. I. A. Clause Unfair.—In the code of ethics of the A. I. A. is a clause which permits an architect to take on the construction of any building for an added fee, but it expressly enjoins him from assuming any responsibility for the financial outcome to the owner. We contractors cannot help feeling that this is not only unfair but that it is highly significant and suggestive. In the construction of a new water supply system of a western city a few years ago, six contracts were let covering a bond issue of about three million. The board felt that some of the bids were too high but finally decided as a matter of policy to let the contracts. Every one of those contractors lost heavily—the total loss being in the neighborhood of a quarter of a million, but every one of them went through without default or delay and the city got its system for its bond issue. Was the contractor in this case an asset or a liability? Such cases could be multiplied without limit.

Public Interest Demands Contractor.—In the last California legislature a bill was introduced which provided that State officials were free to do State construction of highways, hospitals and other work with their own forces by day labor if they desired, but in such case they must first call for bids in order to determine what contractors considered the job worth, and then file with the Board of Control the engineer's estimate of what he considered it worth. Then when the job was finished he must file a sworn statement with the county clerk of what it actually did cost. Is there any reason why an honest official would object to giving this evidence to the people of whether their money had been economically spent? If the State highway engineer, who was spending millions on day labor work, was beating the contractors' bids he would, of course, have been proud to show that he was. This bill was passed unanimously by the San Francisco and Los Angeles Chambers of Commerce, by the Merchants and Manufacturers Association and by many prominent private interests. Nevertheless it was pocket vetoed by the governor without explanation or comment. A similar bill became a law in the State of Minnesota a couple of years ago, with the result that, with the filing of actual costs of work done by official forces, the people are scrutinizing the results and filing their protests against the method and day labor work has been greatly checked. It is not to the public interest to eliminate the contractor.

Creators—Not Gamblers.—To summarize: The constructor is the precursor of every form of human activity. He cannot be spared. We, like you, are personal service agents. That is the only thing we have to sell. We are creators, not gamblers. The things other men produce remain only materials, commodities, passing through many hands and growing constantly more costly but not more useful, until finally the constructor takes them and transforms them into permanent structures, accomplishes their final destiny of usefulness to man, from which there is no further change. If he fails to do his work well, all that has gone before has failed, too. If he does it well, he is the fruition of a thousand hopes. Is such an agent to be hampered by distrust and injustice? Or should he be upheld, and helped, and encouraged? Should we secretly rejoice when we get the work of his hands for less than it cost him, or should we want him to be well paid for work well done? Should we undermine him and set him aside and find ways to do his work without him, or should we build him up in honorable usefulness and strengthen his character and his hands for this special service to society? As he does his work well or ill, so communities thrive. Failing dams destroy property and life. Poor highways impoverish and discourage States. Shoddy homes breed bolshevism and despair. If then, he does his work well, should we not accord him both honor and reward? There was a day when the honest and skillful constructor stood highest in the social order and it was a good day in history.

Urges Attitude of Trust.—Finally, I return to my major topic: "Co-operation." In all the transactions between men, their relations to each other are primarily determined by their attitude of mind and this in turn is largely the resultant of their estimate of each other. If I have before me a business meeting with a shyster lawyer. I approach it with a prejudice and suspicion which at the outset makes it almost impossible for us to work together, even though he might be in a position to serve my interests and be willing to do so. But if I have the same matter in hand with my banker, whom I have long trusted, our minds meet at once and the result is quickly and efficiently reached.

Contracting as a Systematized Business.—Contracting once was largely a gambling game that encouraged and developed sharp practices; today it is a highly systematized business conducted in all its larger activities upon a scientific basis. Once it operated under crude methods with primitive equipment; today it succeeds only by the highest efficiency, and is supported by a vast organization of designers and manufacturers who furnish it with highly specialized equipment for its efficient conduct. Once it was led by strong but untrained men, who by force of character or shrewdness had fought their way to the front; today its great forces are directed and co-ordinated by men of trained minds, of sterling character and of the highest ideals. The old unfair contract was the natural development of the old condition; today it is an obstructive misfit. Engineers are devotees of efficiency; you are its greatest bulwark. But efficiency in construction will always be based upon co-operation between the engineer and contractor. And such co-operation must rest upon a fair contract and upon mutual confidence.

A. G. C. Promotes Fair Play.—The Associated General Contractors, in working for this fair contract, is an organization of great power, with no aims that are not in public interest, with no secret activities, no veiled propaganda, no accumulated fund, no selfish purposes. Its administration passes at short intervals from group to group, over all parts of this country. Its ethics and objectives are as fine as any. This organization now says to the engineers and architects: "This is the new order we are bringing to pass, this is the new day in our great industry which we are hastening. You are our natural allies. We cannot succeed without you; so will you not stretch out your hand to us, divest yourselves of that old mental attitude of fear and distrust of us? It is now an anachronism, it 'doesn't belong.' Give us at the outset a contract that doesn't assail our self-respect, doesn't announce in advance your expectation that we will prove both incompetent and dishonest. Help our success in our work by the same promptness and efficiency on your part that you demand of us. Stop letting us pay for your mistakes and omissions See that we get our progress payment on the day it is due. Be zealous to give us the final acceptance at the earliest possible moment. See through our eyes, too. Treat us as you would if we paid half your fee. And learn then how marvelously our common life-work can be lifted up.

"But most of all, we ask you to recognize that the old order has passed away, that the successful contractor of today deserves your confidence and respect, and that the construction industry and the vast public interests dependent upon it are entitled to results which can be achieved only by real co-operation between you and us."

Openings for Engineers in U. S. Coast and Geodetic Survey.—The U. S. Civil Service Commission, Washington, D. C., states that there is urgent need for eligibles to fill positions of junior engineer and desk officer under the United States Coast and Geodetic Survey, and that an examination for such positions will be held on Dec. 13-14. A prerequisite for consideration is that applicants shall have completed at least 3½ years of a course in civil engineering leading to the degree of B. S. or C. E., in a college, university, or technical school of recognized standing. Graduation with one of these degrees will be required before appointment. The usual entrance salary is $2,000 a year, in the temporary grade of junior engineer and deck officer. Vacancies in the various commissioned grades are filled by promotion, after six months' satisfactory service. An act of Congress provides that the Commissioned personnel of the Coast and Geodetic Survey shall at all times receive the pay and allowances, including longevity pay and all retirement privileges, of the officers of the Navy with whom they hold relative rank.

Municipal Street Railway in Tokio.—The municipally owned and operated street railway of Tokio, Japan, has a total mileage of 1,778 and carries an average of 1,097,633 passengers daily. The railway has been operated by the city since 1911.

Engineer and Accountant in Public Utility Development

Related Functions of the Two Discussed in Paper Presented Oct. 3 at Annual Convention of the American Electric Railway Association

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Points of Contract.—In dealing with the subject of the relationship of the accounting and engineering departments, we must keep in mind the places where their respective work dovetails. To make our premises certain, it should be noted that the term "engineering" as herein used covers both construction and operation. And therefore the accounting engages the engineering department when money is being devoted to new property and extensions and also when being spent in rendering the service for which the utility is designed. The two divisions of engineering are in some companies separate and distinct, but the accounting department remains a unit and logically provides for both through its proper capital accounts and expense accounts. Even when one engineering organization handles both operation and construction, due apportionment of the expenditure is or should be reported to the accounting department.

Hence the contact between the accounting and engineering departments is as broad as the business itself, and the accounting department may prove to be most helpful to the engineering department in any effort on the latter's part to secure low construction and operating costs through the furnishing by the accounting department of the necessary details of cost correctly allocated to work under consideration.

The Attitude.—Some of the drawbacks that have operated against any accurate and searching analysis of the business being made in the past were the positions assumed by the two departments. At times, of course, as well as at different places, it took on the form first of opposition and then again that of utter disregard with occasionally a sprinkle of toleration.

The nature of the training of the men that constitute these different departments has had much to do with the condition.

In consequence of the fundamental training of the two classes of men—is not at all surprising that the two distinctly opposite in character—it departments may sometimes be at variance on points bearing upon their joint duties. Differences remaining unreconciled manifestly contribute nothing to progress. So where such conditions may exist, it is important to change the attitude of both the accountant and the engineer where their views may run in narrow channels as a result of restricting their knowledge, and attention to the immediate requirements of their own specific duties. Hence a little thought given to the requisites of the other follow's work inevitably develops a sympathetic understanding.

The Meeting Ground.—While these problems with their human side are generally known, the solutions applied are not always undertaken in the most beneficial way. If the men who are engaged in these complemental duties were to individually possess a reasonable conception of what his fellow-worker has to do in carrying out his end of the business, there can be no doubt that the desired progress would be promoted. As it is not to be expected that they will as a rule be able to acquire the necessary general knowledge of the routine of the related departments without being directed in some definite manner, proper instructions should be formulated. If, then, the two departments should literally speaking, hold forth on the "ridge" which divides them and observe jointly and studiously the other's field of endeavor, they will plainly see the need of information by one another, which previously had never been thought of or appreciated by them.

The practical application of the idea may be accomplished through any or all of the following means:

1. Joint meetings and discussions to elucidate in a rudimentary way the procedure necessary to successfully carry out the work of each department.
2. Prepare simple notes for exchange describing the elements that must be cared for in fulfilling the functions of the two departments.
3. Provide diagrams and such other illustrations as will show graphically the true nature of the other department's work, so as to visualize in the case of the engineering department how the equipment is arranged in order to provide for the service; how the operating force is organized to maintain the service, and furthermore the significance of the different classes of service or charges obtaining to be graphically illustrated; and then for the accounting department, the manner in which the information and costs are routed in order that all expenses are properly distributed and placed on record and afterwards recast for the various purposes of the business.

There is nothing novel in the above discussion as steps have been long since taken by various utility companies to improve organization efficiency along such lines.

The educational benefits derived from meetings of company sections or special staff or interdepartment conferences of the companies are of the character covered by the first proposition. In the case of the second we find the companies' own classification of accounts often supplemented by explanatory notes which guide the construction and operating departments in reporting on work done.

Some Present Considerations.—Although it is safe to say that there never has been a time when it was not desirable to co-ordinate the accounting and engineering departments, the importance is now vitalized by the fact that while public service regulation is becoming more rational, it is nevertheless exacting greater proof of the facts. Valuations not already undertaken must some day be determined, and careful and consistent records provide a firm foundation. Expense must be distributed to the proper accounts in conformity with established rules. Depreciation must be taken care of as it is a part of the law and the reserves to be set up are to be based upon the proven needs of the business. More statistical information is required. And, further, cost accounting could advantageously be carried out in much detail.

All of these new conditions obviously bring the accounting and engineering departments in closer relation with one another. Each of the topics enumerated in the above paragraph would separately give rise to voluminous discussions, but an outline reference to some salient points will bring out forcibly the co-operative action demanded of the two departments.

Valuations. — There are various property values that might be mentioned, viz.: Market value, book value, investment value, value for taxation purposes, and value for rate-making purposes. Eventually one value of the public utility will become predominant for all purposes, and that is the much discussed fair value regarding which we still find a wide divergence of opinion among engineers, economists, lawyers, the commissions and our courts. After all differences are ultimately rationalized, and common principles of valuation universally adopted, the accountants' records will then become controlling for rate regulation and likewise in an equally strict sense in all business matters of the utility corporation.

To accomplish this end, a complete system of authorizations, requisitions and work orders must be enforced where they have not already been put into effect, or where they have been treated in a perfunctory way. The work covered must be set forth very clearly and sufficiently described by the engineering department so that the records will always be self-explanatory, and in addition, accurate when completed in the accounting department. As the work progresses, the engineering departments must exercise particular care that all charges are properly designated and assigned to the account to which they belong. When the charges are received by the accounting department, there must be no question as to their being placed against the proper authorization and accounts, and after the work is completed it must be certain that the cost will be shown in full. The diagrams and descriptions of the work prepared by the engineering department, above referred to, will enable the accounting department to apply somewhat of a check as to the correct distribution of the various charges, some of which may not have been clearly assigned. One of our railroads introduced a very elaborate system of check accounting years ago and had prepared tables listing every item and detail that might enter any part of a specific piece of construction. While this is evidently carrying refinement to the extreme, no doubt following this plan out in considerable part will do much to increase the reliability of the accounting systems.

The accountant has the duty also of properly allocating all overhead expense and entering the due portion against each construction job. Part of this overhead may be best determined by a discussion of the details between the accounting and the engineering departments.

Extensions and improvements should, of course, absorb the greater part of the attention of the accountant and engineer. However, as the property grows, certain equipment becomes obsolete and is abandoned for its inadequacy and lack of utility when it still possesses serviceability. The disposition of the accounting in such instances requires special treatment, for the history of the case must dictate what corresponding value, if any, should be written off the books. It also depends upon whether the business has permitted the amortization of such equipment before it is retired or else it is to be carried temporarily as a deferred charge to be gradually wiped out through future earnings. Or, it may be necessary to capitalize the account as a developmental expense of the business if it can be proven that this is the most equitable way under the particular cirmumstances.

Thus the accountant and the engineer have many problems which must be jointly solved by them.

Cost Accounting.—Figuratively, an epidemic of cost and efficiency systems seized the industries, chiefly the manufacturing branch, several years ago. Leading manufacturers felt the necessity for more definite cost analysis in order to ascertain wherein competition could be best met and also which products really produced the greatest net profits. While the public utility is on an entirely different plane from that of the producers of equipment and commodities, nevertheless, it is required to differentiate between the various classes of service it renders.

In the first place, we must have cost accounting to establish our construction expenditures in a precise way. Not only do commissions require it but the bankers who finance utilities are beginning to insist upon an adequate record being kept of all disbursements of funds.

Unit costs are derived when the cost accounting system is complete. These unit costs will afford an opportunity for comparisons as to relative efficiency and economy with which the work has been done, and also provide a more positive guide for future estimates.

Presently the arriving at the cost of rendering various kinds of service in a more methodical way will become quite general. Although every utility at this time has means of testing the adequacy of its various rates, fares, and charges, there is no doubt always room for improvement.

The facts that cost accounting will display, will enable the utility to carry on its business with greater certainty than heretofore. It should also be in a stronger position to absolutely defend whatever rules, rates and system of charges it has or may put into effect. Results as here indicated are only possible through the earnest efforts of the accountant and engineer effectively combined.

Replacement and Contingency Reserves.—Every business which has to deal with physical property—man-made—must make provisions for the restoration of equipment and structures that are subject to wear and tear, age and the elements, and likewise to accidents and unforeseen happenings. Albeit, life tables of various buildings and machinery have been published and it has also been customary to set aside arbitrary percentages (referred to capitalization, gross earnings or output) which have served their purpose exceedingly well in the past, we must now take up these questions in an intelligent manner if we are to make the whole scheme of the utility operation consistent.

Whether the straight line methods, the reducing balance method, the sinking fund method, the annual payment method, actual depreciation or other means be adopted, it should be such as would clearly indicate to the accountant and engineer that the necessities of the business will be provided for, however without building up such reserves as may check the growth of the business in a degree, or cause too great a contribution from the present patrons. Although these latter conditions are rather remote, they are merely mentioned as possibilities.

The requirement in the case is that the engineer and accountant jointly work out some feasible plan of taking care of reserves based upon sound principles and experiences of the business. This need had been recognized long ago by the American Electric Railway Association in appointing a joint committee of accountants and engineers to report on the underlying conditions and facts of this phase of the business for the benefit of its membership.

Conclusions.—These generalizations, it is believed, will point out the closer contact between the accountant and engineer that has come about through State and Federal regulation, and also from intensive development of the business.

Many subjects of mutual consideration are noted which should pave the way for a profitable "get-together" meeting of the active members of these departments. Opinions, as may now be held, unquestionably stretch over wide ranges, but these differences will be effectively narrowed down if a plan of reciprocal enlightenment is pursued by the clearing-up of the obscure side of one another's work. The accountant should pay just enough attention to the engineering to understand the principles of valuation and the general construction and operating features of the business. The engineer, however, should appreciate the essential elements of accounting, and those in more important positions should even acquire a reasonable understanding of the "elusive" balance sheet as so often considered. Admittedly, the line must be drawn somewhere, but the limitations in each case must rest with the judgment of those who direct the utilities' affairs.

In this connection one of our leading technical institutions, to my knowledge, perceived the necessity of the engineer's possessing a general knowledge of accounting and accordingly introduced a course in bookkeeping and accounting into its curiculum about 20 years ago. On the other hand, I personally know a number of accountants who have entered high schools or taken correspondence courses to learn the general principles of engineering so they could better to grasp the technical side of the business with which they were connected. This broader education of both the technical and accounting divisions is in response to the requirements of modern business.

In building up an organization with attendant selection of employes for both engineering and accounting work, it is evidently desirable that the qualifications of the applicants or other potential timber, be broad enough to fit them for their particular responsible ties not only with reference to their immediate duties but also as regards other departments of the business. It is doubtful if sufficient consideration is given this phase in the development of our complex institutions such as a large utility may be termed.

A great many employes already are quite conversant with both divisions of the work (engineering and accounting) but the aim of this paper is to encourage the developing of more men of such qualifications, as this is bound to enhance both the efficiency and integrity of the organization.

Although the subject may indicate that the discussion is restricted to the action of engineers and accountants, it is evident, of course, that principles and ethics which should govern them apply in no less degree to all whose duties make them a part of the "mechanism" designed for dependable and instructive accounting and analyses.

It would be folly to impugn that co-ordination did not exist to some degree, more or less in every organization. Manifestly, co-ordination is to the organization what spirit is to the animate being. In point of illustration, the flesh and blood may exist in a perfect state, but without the proper amount of spirit the effectiveness of that being must be limited. Likewise, the different departments of an organization may be ever so good within themselves, but without the essential spirit of co-operation with allied departments, the strength of the organization is impaired.

In concluding, the author wishes to make it clear that no over-reaching is to be permitted in the apparent attempt to idealize our working conditions, as all systems in business are in a practical sense restricted within reasonable bounds; however, any time and effort expended to increase the opportunities of the respective departments and their individual constituency must be fruitful.

Sales of Explosives in August.—Sales of explosives in the United States during August for domestic consumption amounted to 603,842 kegs of black powder, 3,280,800 lbs. of permissibles, and 18,114,953 lbs. of other high explosives. These figures are based upon manufacturers' reports to the Federal Bureau of Mines and represent about nine-tenths of the explosives industry. During the first eight months of the present year, 3,1117,563 kegs of black powder, 20,195,620 lbs. of permissibles, and 112,647,455 lbs. of other high explosives have been sold for use in the United States. As compared with the corresponding period of 1921 and 1920, the figures represent decreases of 6 per cent and 54 per cent respectively, for black powder; deacreases of 15 per cent and 42 per cent, respectively, for permissibles; while other high explosives increased 12 per cent over 1921, but were 25 per cent below the amount sold during the first eight months of 1920. Of the total quantity of explosives sold from January to August, 1922, the mining industry has used 85 per cent of the black powder, 95 per cent of the permissibles and 49 per cent of the other high explosives.

Stripping With Steam Shovels in Russia at 50° Below Zero

American engineers would hesitate to strip coal at a time when winter gales such as blow in Russia sweep over the ground, for the mercury frequently hovers around 50° below zero, freezing everything to adamant. But in parts of Russia the need for fuel requires that the attempt be made, so in spite of obstacles, steam shovels and draglines, winter and summer alike, are digging coal in the Ural region. The difficulties of the task and how they were overcome were described in Gornoji Djilo, the journal of the Mining Board of the Supreme Council of Public Economy, by Saitzevsky and translated by George A. Moskchansky, an engineer. The translation is given in Coal Age as follows:

For a long time the excavating work in northern Russia began in April or May, according to the location and readiness of the ground to thaw out, and lasted until November, and sometimes only until October. Thus the work was prosecuted from five to seven months, or an average of about half a year. The rest of the year excavators were not in use, though in southern Russia they work the whole year long.

During the present period of national reconstruction the demand for excavators continually grew and as it has been impossible to obtain these machines abroad for the last three years and as they are not built in Russia, it seemed absolutely necessary to utilize the machines on hand to the utmost, making them work not merely half time but throughout the year. Many experts in coal mining questioned whether winter work was practicable, especially in the northern parts of Russia.

Michigan Mines Strip Ore in Winter Months.—In foreign technical literature there are descriptions of the stripping of coal or ore by excavators during the winter. Thus, in the March, 1918, issue of the Engineering and Mining Journal an article describes in detail how ore is stripped every winter near Lake Michigan so that it may be loaded early in the spring, ready for shipment to the plants as soon as navigation opens.

It was known also that during the building of the Murman R. R. excavation continued during the winter, the military necessity requiring that the work be speeded as much as possible. This work was performed in an extremely severe winter, not differing much from the climate of the Urals, with temperatures of —58° F. This suggested to me that the excavating work in Cheljabinsk coal mines could be extended through the winter months. This project has been accomplished and in the strip pits of this northern country, three steam shovels of American manufacture have been successfully used. The ground consists of a sandy clay. The depth of the cut where the Bucyrus works is about 12 ft., the shovel standing on the coal and loading the overburden into cars standing on track laid on the surface—that is, at a height of about 34 ft.

The shovel moves from north to south along the eastern side of the cut and the two Marions move from south to north along the western side while going deeper by steps or banks on an inclination of 1 per cent. The material is lifted only a few feet, the booms of the shovels being short.

In December, 1920, the Bucyrus worked steadily by day and by night, loading from 800 to 1,000 long tons in 24 hours and uncovering between 700 and 750 gross tons of coal. The Marions for a while performed a preparatory work, gradually going deeper in four cuts, each 4.8 ft. deep, and having behind them the pit about 19½ ft. deep. One of them is now almost at the beginning of the cut, another one in the middle digging a low bank, consequently their work is not efficient, but after reaching the depth of 16 to 19½ ft. they will scoop a full dipper load at each movement, whereas they now fill the dipper only by making many strokes. With banks of the regular height they will move in 24 hours not less than 1,635 cu. yd.

Draglines Also Working in Russian Winter.—Beside the excavators just mentioned a Bucyrus No. 14 dragline excavator is working in the southern cut of the Cheljabinsk mine. Beginning its work without a preparatory blasting of the frozen surface the bucket of the excavator broke, temporarily suspending the operation of the machine. It must not be thought that work cannot be done with this machine during winter months, for it can be successfully operated if the frozen top crust is first thoroughly prepared by blasting. To prevent the cut from freezing, the work must be continuous.

Winter work is not insuperably more difficult than work in the summer. If it is prosecuted in three shifts the ground is not given time to freeze up, and the machine has difficulty only in removing the top crust. To facilitate its digging the crust is prepared by blasting a number of holes drilled in checker order 2 ft. 4 in. from each other and 27 to 35 in. deep. The holes are charged with soft dynamite, each charge being 0.112 lb. They are drilled at an angle of 45 degrees to the surface, with the slope toward the bank.

Bucket Readily Scoops Up Frozen Lumps.—After the holes are exploded the frozen crust is cracked in all directions, and the dipper of the excavator without much difficulty scoops the upper part of the bank, which readily breaks into lumps.

Preparations are being made to drill the blast holes with air drills. When the work is done by hand a workman in one shift with the twist drill will drill ten holes. It seems difficult to explain how so much work can be done until it is stated that the upper layer consists of soft black soil. Where, as in some places, the top consists of clay, air hammers have to be used.

When the ground is thus prepared for excavation the work is made relatively easy, so that the resistance of the ground to the shovel is little more in winter than in summer. The main difficulty is to protect the intake and exhaust steam pipes from freezing, to supply the machines with water, and to protect the workmen from cold and wind.

In Cheljabinsk mines, on account of certain misunderstandings and friction, the winter work in 1920 was started almost without preparation, the precious months of the autumn being allowed to pass by without anything being done. Operations were begun in the latter part of November, when cold, windy weather came on, the temperature falling to —50.6. At the start the steam in the pipes condensed rapidly, and the pipes, cylinder heads and valve chests froze up almost instantaneously whenever work stopped. The pipes, cylinders and other parts of the machine where water was likely to gather, had to be covered with insulation. The machine was covered with a wood shed, but this proved an unsatisfactory protection.

To supply water for the shovels was an unusually difficult task. As in coal mines the water is very hard, it usually was delivered in sheet-iron tanks, but in winter these proved to be useless, for the valves froze up when the water was shut off. The Omsk R. R. furnished the excavators with fourteen box cars each containing two water tanks of an aggregate capacity of 2,650 gal. These box cars are heated by stoves. The discharge valves are inside the cars and consequently do not freeze. Thus protected the tanks give satisfaction. The feed water for the boilers is brought in these tanks 14 miles from a point on the Omsk R. R.

For these cars a separate track is laid alongside that provided for the equipment on which excavated material is loaded. Water is delivered to the excavator tanks through a 2½-in. hose.

Shovel Lost Much Time Waiting for Cars.—Success in excavating work depends largely upon the track facilities and the prompt arrival of cars. The efficiency of the excavators during the last working season was from 15 to 40 per cent of normal and the latter figure was reached only lately. This lack of efficiency can be laid almost exclusively to the unsatisfactory condition of the service tracks. The machines were frequently idle, sometimes as much as 75 per cent of the working time being lost waiting for the locomotive and cars, which were delayed by reason of derailment of loads and from other causes.

The Omsk R. R. is greatly interested in the production of this coal, being itself the chief consumer of the product. Consequently it took the shipping part of the business in its own hands, placing in each department responsible agents appointed by the department manager of this division of the line. As soon as this was done the machines were enabled to keep busy, the tracks and cars being kept in good order and locomotives arriving at stripping machines as they were needed. This also aided the winter work materially. Had it not been that the Omsk R. R. took over the hauling of the trains and the supply of water, the removal of snowdrifts, the thawing of the tanks, and other haulage and water-tank equipment difficulties, winter work would have been impossible.

In order to avoid the freezing up of the banks the shovels were kept as far as possible in steady operation, stops being made for only short periods when it became necessary to make repairs, replace broken parts and do other necessary work. To this end the pit was operated for three shifts despite the fact that less is done at night than can be done during the day.

Care should be taken to light the pit and dumping place adequately. Incandescent electrical lamps are not altogether convenient for this purpose. When they are placed on the machine itself they are subject to much vibration and burn quickly. It is therefore more convenient to erect posts behind the machine and mount them on these.

It was found important to provide the excavator gang with clothing of unusual warmth. It was not sufficient to provide them solely with the usual fur coats and felt boots. Cotton underlined trousers and coats and the felt caps of the new Red Army style were provided. This headgear protected the back of the head, the ears and even the cheeks.

Cannot Work Full Eight Hours in Cold.—This type of equipment though light, is warm and does not hinder the free movement of the men in the excavator gang. Yet even in garments such as this it was impossible to work continuously for eight hours in the cold and wind, and the gang, consisting of an engineer, a trackman, an oiler and a fireman, had to be reinforced by a second engineer and trackman, their work being the most responsible and requiring special activity. It is also the most uncongenial work, for the trackman is not protected in any way from the wind and cold. Consequently it is essential that during the shift he have an opportunity to warm up at the boiler of the excavator shed.

Snow fences must be erected to prevent the accumulation of drifts. At the beginning of the work the trench filled with snow, the dipper scooped up snow with the ground and this formed with the clay a sticky mass, which adhered to the dipper so that it could not be discharged. Consequently the work had frequently to be stopped while the dipper was cleaned by hand.

The unloading of cars at the dumping place also was a difficult operation. The cars were loaded in from 25 to 30 minutes and the dumping took about an hour. Each flat car required about five or six workmen to unload it, and on the twelve flat cars of a single train about fifty or sixty men were employed. These workmen throughout the shift ride between the cut and the dumps, the distance being about 1.8 miles. They are exposed constantly to the cold and wind, as the dumps are located where the ground is level and unprotected and where consequently the wind has a clear sweep.

Dump cars have as yet not been provided, but they are under construction and probably soon will be in operation. If not, then the unloading should be done by a plow. Thus unloaded the work could be done in not more than five minutes instead of, as at present, in an hour. This will reduce considerably the number of work trains and decrease to a large extent the number of men performing this exacting work in the bitter cold.

Training Engineering Executives

Co-operative Work Massachusetts Institute of Technology Is Doing with the Electric Railways Described in AERA

BY WILLIAM H. TIMBIE,

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The prosperity and a proper scale of living of the nation depend in no small measure upon the rational development and successful operation of electric street railways and suburban lines. The discontinuance of lines for any cause (other than lack of patronage) would mean the embarrassment of millions of people who, because these railways furnish excellent transportation facilities, have built their homes in pleasant and healthy suburbs of the large industrial and commercial centers. Nearly a third of a million people depend for their livelihood upon the employment offered by electric railway companies and thousands more have risked their savings in the stock of these public utilities.

Electric Railways Necessary to Industrial Development.—The electric suburban line has furnished about the only solution to the problem of proper housing for the workers in our crowded industrial centers. The time is rapidly approaching when this country must rely almost entirely upon its manufacturing industry in order to support itself. No longer can we depend upon our exports of raw materials to pay our bills. These raw materials, lumber, ores and oils must be manufactured into finished products if the living expenses of the population are to be met. Large as our manufacturing and commercial centers are at the present time, they must become still larger and more numerous. With this industrial growth must take place the development of the territory surrounding these industrial centers into pleasant, healthful home sites. The problem of furnishing comfortable, convenient and regular passenger transportation between factory and home for millions upon millions of industrial workers is not a whit less important to the prosperity of the country than the problem of securing a most economical transportation and distribution of raw materials and manufactured products. Both problems are worthy of the whole effort of the best minds in the country.

The electric railway problem is divided sharply into two parts which are equally important and both of which must be recognized and solved by any electric railway company which is to succeed.

Education Problem Is Twofold.—First, methods and courses of training must be instituted for the present personnel of the company to bring them to their greatest effectiveness. Opportunity must be given to every man to study and make progress along the line for which he is best suited so that he may eventually advance to the highest position for which he is mentally and temperamentally equipped. Probably much of this training can best be given by the company. The Massachusetts Institute of Technology plan, however, as outlined below, gives these men not only the advantage of company training, but also instruction offered by a well organized night school which it has successfully conducted for many years.

Second, in addition to training the present personnel, the best engineering and administrative talent must be attracted to the company. There must be a steady influx of new blood with its new ways of looking at old problems and its fresh enthusiasm to tackle the problems. It is not sufficient that merely new blood be brought into the organization. This new blood must be highly trained in modern science and in the scientific method of thinking. It must bring ideas with it, and not depend upon those already worked out. The very best brains in the country must come into intimate contact with the problem and must remain with the problem long enough to grasp it thoroughly in all its details and bearings.

Two Problems to Be Carried Out.—As stated above, a modern electric company must formulate and carry out plans for doing both of these things, i. e., train the present personnel to the limit of its capacity and from time to time attract new high class talent into its service. That company which puts all its efforts upon educating its present force will soon realize the disadvantages of inbreeding and the hampering of traditions. It will not recognize the possibility of using the latest discoveries in science nor will it feel the push of the fresh energy and enthusiasm which would come to it when new men are brought into the organization. On the other hand, the company which puts all of its efforts into getting new blood into the organization will not be able to keep the loyalty of its personnel. The loyalty of an organization depends largely upon the knowledge that the company has a fixed policy of advancing the men in the force as rapidly as opportunities occur and individual ability permits. Thus it is necessary that each company should maintain simultaneously these two branches of training and each branch must be a whole souled, honest effort at real education.

The M. I. T. Plan for Training Executives.—The plan proposed by the Electrical Engineering Department of the Massachusetts Institute of Technology for training electric railway executives has the unique merit of providing training for both groups of executives.

For the skilled workmen and minor executives it maintains a two-year evening courses, called the Lowell Institute Course for Industrial Foremen. This course offers to men employed during the day with electric traction companies and already familiar with the practical details of electrical transportation the advantages of scientific instruction in the fundamentals of electrical engineering.

For the training of the higher executives, the Institute proposes to operate a five year co-operative course for electric railway engineers. This course will be similar to the co-operative courses already in successful operation for training electrical engineers for manufacturing industries and for large power companies. This course will offer to a selected group of mature students at the Institute the opportunity of becoming familiar with the problem of operation and organization in electric traction companies at the same time that they are requiring the scientific principles of electrical engineering.

Lowell Institute Course for Minor Executives.—The course for skilled workmen and foremen is conducted in the evening and is intended to bring the systematic study of applied science within the reach of young men who are already employed by an electric traction company and desire to fit themselves for higher positions. The equivalent of a high school education is a practical necessity in order to pass the rigid entrance requirements. The course is of two years' length, the terms beginning the last week in September and continuing into May with one week recess at Christmas. Four sessions a week are held, each being two hours in length. The home work assigned at each session requires about four hours' preparation. The week's schedule, therefore, consists of eight hours classroom work and sixteen hours preparation and study. This evening course has long since passed the experimental stage and the marked success of its graduates is the proof of its effectiveness in preparing a man to advance in his chosen branch.

Co-operative Course in Electrical Engineering.—The details of operation of this co-operative course in the higher branches of electric railway engineering would parallel those which have been in successful operation for three years in connection with the General Electric Co. at Lynn and for one year with the Edison Electric Illuminating Co. of Boston. The student, to be eligible to this course, must be mature and have successfully completed the first two years of the regular Electrical Engineering Course at the Institute. He must also evidence such executive ability and personal qualities as will satisfy the railway company that it is warranted in taking him into its employment and training him for a period of three years. In other words, he must be a man, not an immature boy; must give evidence of superior mental capacity in the acquiring of scientific knowledge and methods, and have the ability to handle men.

The co-operative period accordingly starts with the third year of the work at the Institute. From this time on during a period of three years the student spends alternate terms in the employment of the cooperating company and at the Institute, each term being of three month's duration. The course is thus five years in length, the first two years being spent entirely at the Institute. During the last three years the student divides his time equally between the Institute and the co-operating company. For the completion of this five-year course the Massachusetts Institute of Technology proposes to grant the degree of Master of Science as well as that of Bachelor of Science.

Advantages of Method.—By this method of training engineers for electrical railways, the students, during the last three years of their college training, become a part of the co-operating company as well as a part of an educational institution. They are enabled to interpret their theoretical training in terms of railway practice and at the same time more readily grasp the underlying principles of engineering practice as they find it exemplified in the operation of electric railways. Thus, instead of making a butt joint between a man's study in theoretical subjects and his practical experience, this course joins the two with a dove-tail joint. The student enters the industry gradually and his interest is aroused more naturally than by any other method.

It is to be particularly noted that the Institute does not propose to teach electric railway practice in the classroom and laboratories. It believes that the function of the educational institution is to teach thoroughly the principles of science and the method of applying these principles to practice. The practice itself can much better be obtained in the field. It does not attempt to bring the practice into the school, but tries to bring school methods of instruction into the shop and office during the alternating periods when the men are at the company's plants obtaining their practical experience.

Courses at Company's Plant.—The length of the terms at work are sufficient to avoid frequent changing and permit the student to become well acquainted with the details of operation of any department and interested in its methods. His periods at the Institute coincide with the regular Institute terms. The periods spent with the co-operating company are made doubly effective in the mental development of the student by means of courses conducted at the company's plant by members of the instructing staff of the Institute. While at the works, the student continues the study of two of his important subjects, i. e., a course in electrical engineering and some liberalizing course. By this means considerably more than four year's work in the subject of electrical engineering is completed and six terms of special subjects are taken up. A brief description of some of these subjects will serve to indicate their character.

There is a course in Business English to give the student practice in the preparation and delivery of technical papers in order to furnish him sufficient training in public speaking to enable him to address boards, advocate engineering projects, or present papers before professional societies. It also includes work in Business Correspondence and Office Methods for the purpose of teaching him the value of individuality and personality as well as the use of correct and precise English in business correspondence. A course in Corporation Accounting is required in order to familiarize the student with the principles of general accounting as applied to large organizations showing him the ordinary methods of financing companies and enabling him to interpret intelligently balance sheets, financial statements, etc. An applied course in Business Psychology is also given for the purpose of aiding the student to understand his fellowmen, that he may know how to work in harmony with them, not only while he is in subordinate positions, but also in positions of responsibility. A brief history of electric railway development is studied in order to bring out the background of the present situation which electric railways hold in civic, industrial and engineering activities of the nation.

The Student's Time Schedule.—In order to carry out successfully the appended schedule of studies, the student's time schedule is as follows:

When with the Railway

3 hours per wk. classroom.
6 hours per wk. preparation for class.
48 hours per wk. in employment of company.

When at the Institute.

20 hours per wk. in classroom.
28 hours per wk. preparation.

Range of Experience with Railways.—Below is an outline showing a student's progress through the various departments of a company. It will be noted that he is scheduled for periods varying in general from two weeks to six weeks in practically every sub-department. The last five weeks are reserved to be spent in that department in which the student wishes to specialize.

Maintenance Department.

Surface Lines Track Dept.:	
Track building	3 weeks
Welding	2 weeks
Equipment Div.	2 weeks
Tie and timber treating plant and general yard	3 weeks
Rapid Transit Lines track	4 weeks
Steel Maintenance and Erection Division	5 weeks
Signal Division	5 weeks
Building Division	4 weeks
Department of Rolling Stock and Shops.	
Car house pits	4 weeks
Rapid Transit shop	4 weeks
Armature shop	2 weeks
Machine shop	1 week
Truck shop	1 week

Transportation Department.

Switchman	1 week
Conductor	3 weeks
Motorman	3 weeks
Div. and car house office	3 weeks
Time tables and traffic	4 weeks

Power Department.

Wire and conduit division	4 weeks
Power station and substations	4 weeks
Electrical engineering	4 weeks
Architectural Dept.	1 week
Civil engineering	2 weeks
Mechanical engineering	2 weeks
General manager's office	2 weeks
Five weeks of specializing on branch of business selected by student and management.	5 weeks

Status of the Student Engineer.—While with the railway company, the student takes his place as an employe of the company and is expected to the best of his ability to perform all duties and carry any responsibility the company may put upon him. While it is true he is with the company for the purpose of receiving education and training, it is equally true that he is not there as an observer but as an employe and as such is expected to render every service demanded of him. The whole plan consists simply of putting into practice the educational principle, "learn by doing."

General Applicability of Courses.—The co-operative course, outlined above, can be operated in conjunction with any railway company within a radius of three hundred or four hundred miles from the Institute. The Lowell Institute Course, on the other hand, must be limited to men residing in the immediate vicinity of Cambridge.

Additional Power for Winnipeg Street Railways.—For the purpose of developing additional hydro-electric power on the Winnipeg River, a new company has been incorporated under the laws of Canada, subsidiary to the Winnipeg Electric Street Railway Co., says Consul General Brittain in a report to the Department of Commerce. The municipality of Winnipeg is also is a potential capacity of 168,000 H. P. will be used particularly by the street railway company, and also for manufacturing industries and domestic purposes in the city of Winnipeg. This additional power of which there contemplating extensions to its power plant at Lac du Bonnet, on the Winnipeg River, about 15 miles from the proposed new development.

New Freight Shipping System By "Container Cars" of New York Central Lines

The new system of freight shipping by "container cars," just inaugurated regularly after exhaustive tests on the New York Central Lines, was described in an address delivered Oct. 10 by F. S. Gallagher, Engineer of Rolling Stock, before the Society of Terminal Engineers at New York.

The steel "containers" give the shippers of less-than-car-load lots all the advantages of the carload shipment and additional benefits, through carrying shipments under utmost protection against pilferage or damage from the door of the sender clear to the door of the receiver. The "containers" are steel boxes, six to nine of which fit sectionally upon a car behind low steel walls which absolutely prevent their opening in transit. They are hoisted between motor truck and car by means of cranes, thus quickly releasing rolling stock and preventing congestion of platforms or tracks at terminals. The "containers" have been used regularly in carrying United States mail for over a year without any loss or damage whatever to valuable consignments; have reduced necessity of sacking mail and have greatly expedited inter-city deliveries. The "containers" permit a shipper to stow consignments on his own shipping platform and eliminate need of costly boxing and crating.

The successful tests of the "container" cars in carrying express and mail matter have now been followed by the establishment of crane equipment for regular "container" service in carrying less-than-carload freight between 33rd St. Station, New York City, and Carroll St. Station, Buffalo, N. Y., the "container" cars leaving each terminal Tuesdays and Saturdays. Special rates have been established under tariffs published with the approval of the Interstate Commerce Commission. These provide rates for a minimum of 3,000 lbs. up to the maximum capacity of a 7,000-lb. load for each container.

Mr. Gallagher, in describing the new system before the Terminal Engineers' Society, said in part:

Although the container system of handling less-than-carload freight is too young in years to furnish definite or concrete figures as to costs, we are able to show success in economy and safety effected through the new method.

The accomplishment of a means of loading or unloading a car of less-than-carload lots of freight within a few minutes alone carries far-reaching potential benefits, when we take into consideration the railroad equipment of the country and the inability of the railroads to control this equipment of the country and the inability of the railroads to control this equipment during the peak load of business. In times of heaviest demands, it is known that shippers, while waiting for a change in the market, gladly pay the regulation demurrage charges rather than unload the car in which their goods were shipped, using the car as a temporary storage place, and tying up equipment that is badly needed. This condition was very prominently brought out during the war when goods were shipped, especially in this eastern district, to consignees who either could not or did not want to unload the freight, but instead took advantage of the demurrage provisions, which was at an expense to the railroad company for car revenue which they would have had if the car had been unloaded promptly and returned to service, and at the expense of the public at large because of the inability of the railroads to handle greater tonnage because of the lack of equipment.

This condition with the use of the less-than-carload containers should be greatly reduced, if not altogether eliminated, because of the fact that the containers can be removed from the car, immediately taken to the shipper's warehouse, and while there might at some day be a demurrage charge of holding the containers, it would not keep the rolling stock out of service. In other words, the container method of handling freight permits the enforcement of quick unloading, and of course the quick unloading means the quick return to service of the car. During periods when there is a shortage of cars, the quick unloading of the freight car is a benefit to all concerned—the railroads, the shipper and the public.

Thirteen Man-Handlings Now.—The saving in labor and time may be seen by noting, in detail, the number of times that less-than-carload lots of freight must be handled from the shipper to the consignee. Let us follow one package from start to destination: First, it is carried from the packing room to the warehouse platform; second, from the warehouse platform to the wagon by hand truck; third, from the hand truck into the wagon. This is man-handling. The wagon then proceeds to the freight house, where at the platform occurs the next man-handling. The fourth man-lift is from the wagon to the freight house platform, and the fifth from the platform to the hand truck.

The individual package must be weighed, proper records made, and then taken into the car, making the sixth movement. A seventh handling is the stowing into the freight car, after which is attached the seal, which is broken at destination. The eighth handling is by the unloader lifting the freight to the floor of the car for the hand trucker; the ninth, the hand trucker with the package stopping while record is being made of the shipment going out of the car. The trucker then carries this freight to a designated place in the freight house and it is left there.

The consignee is notified that the goods for him have arrived, sends his wagon to the freight house and notifies the delivery clerk. The delivery clerk points out the shipment to the hand trucker, who takes it to the wagon for loading, which is the tenth handling. When the package is delivered by the hand trucker to the wagon platform, it is dumped at the tailgate of the wagon, making the eleventh handling, and must be handled the twelfth time to place it into the wagon. At the consignee's receiving platform, the goods must be unloaded from the wagon, making the thirteenth time that this package has been handled.

Now assuming that a carload of less-than-carload freight were 20,000 lbs., this means that it must be man-lifted thirteen times, or man-power must be provided to lift 260,000 lbs. in order to transfer one carload of 20,000 lbs. of freight. This does not include the numerous checkings and records that must be made of this freight, which in itself is a big item of expense.

By the new system, the container is delivered to the shipper, who, if properly equipped, will have a light overhead crane or some other means of carrying the container into his warehouse, so that one handling of the original package into the container is all that is necessary. The expense of crating is eliminated. When the goods are in the container, the door is closed, and if the shipper desires, he can put his own lock on it. The railroad company would also seal the container with the regular car seal.

Being loaded with one handling of the freight, the container is lifted by hoist from the floor of the shipper's warehouse to the motor truck and is lifted by hoist from the truck to the car.

Particular attention is directed to the security of the shipment when placed on the car. The bottom of the door of the container sets in behind the side of the car, making it impossible to get into the container while on the car, and the container is big enough so that it cannot easily be taken from the car without proper lifting facilities.

At destination, the operation described is reversed. The container is lifted by crane from the car onto the motor truck and then from truck to the consignee's platform, where it is unloaded and may be ready for a return shipment, or it may be picked up by truck for the use of some other shipper. While the container is being unloaded, the motor truck, as well as the railroad car, is released.

Saves Man-Lift of 110 Tons.—Instead of having to handle this container shipment of less-than-carload freight thirteen times by man-power, it is handled twice, saving on the same basis as before. That is, on a carload of less-than-carload freight weighing 20,000 lbs., the saving is the lifting by man-power of 220,000 lbs., or 110 tons. This is an economy that we cannot lose sight of, and while it may be said, of course, that there will be an expense incident to the installation of equipment for handling these containers at the various shippers' and consignees' plants, when this equipment is once in, the expense ceases. It does not cease with the present method of handling less-than-carload freight, because every time a 20,000 lb. carload of less-than-carload freight is handled from shipper to consignee, it requires 260,000 lbs. of man-lifting, while the container system would require only 40,000 lbs. of lifting—a saving in man-lifting power of 220,000 lbs.

Saving Justifies Equipment.—When we started to carry freight by rail, and for considerable time thereafter, facilities for side tracks, shop tracks, etc., into the factories were not provided, but instead the freight was hauled between the railroads and factories by teams. Then somebody conceived the idea that if they had a railroad track into their yards, they could handle their freight a good deal cheaper and with less delay, with the result that a track was put in. Today, the first thought a manufacturer gives to the building of a new factory is, What are the railroad facilities, and how can we get sidetracks into our plant so that we can have our freight delivered by the railroad right into our own plant?

Now, why shouldn't a shipper of less-than-carload freight take into consideration the provision of overhead hoists or other means of handling containers to avoid the necessity of loading the wagon at the shipping point, unloading again at the freight station; then at destination loading the wagon, and at the consignee's platform unloading once more? The time required for loading and unloading the wagons is saved, except the moment it would take to lift the container from the car or station platform to the truck and from the truck to the shipper's or consignee's platform.

Container cars have been in regular mail service between New York and Chicago on the New York Central for many months. In this service, the eight containers regularly are placed on the trucks by overhead crane in seven or eight minutes, and the crane used is not one especially built for the handling of the containers, but a regular freight yard Gantry crane of heavy capacity. If this were a special crane designed for handling containers alone, I think the time required to place the containers on the trucks from the car, or vice versa, would be less than one minute per container.

Loss and Damage Minimized.—We are all familiar with the enormous amount of money returned to the shippers by the railroads and by the express companies on account of loss and damage to freight. On less-than-carload freight it amounts to more than 8½ per cent of the revenue. The express companies pay claims to the amount of $25,000,000 a year for loss and damage.

A great portion of this can be saved by the container system, because there is no chance of damage if goods are properly packed in the containers, unless there is a disastrous smash-up, and no chance of loss en route from the shipper's platform to the consignee's platform, because it is impossible to open the door of the container while on the truck because the solid back of the truck prevents the door opening, and while on the car the sides of the car prevent the door from opening.

The container cars were in express service continuously for nearly two years without any loss or damage to any express matter whatever. I think that is quite a record.

The Postoffice Department, aiming for economy and safety in handling mail, authorized a trial line of container cars to be used between New York and Chicago. These care were placed in service regularly on Jan. 15 this year, and results have been such that the Postoffice Department has authorized the New York Central to continue the service indefinitely.

Construction of Container Cars.—In the container car construction, a solid floor is not used, but instead a wire screen is spread between the steel frame work so that any snow or water that drops between the containers will pass through.

The containers have guide shoes which are arranged to slide between the guides on the sides of the car and hold so firmly that no container can shift about, even if some of the containers are removed.

Container-Tanks for Milk.—I have discussed the container for less-than carload freight, express and mail, but there are other commodities handled by the railroads where the container should play a big part. This includes the handling of liquids, especially milk, fruit juices, edible oils, acids, etc., where temperature is an important factor.

A glass-lined tank built by the Pfaudler Co. of Rochester, N. Y., encased in an insulated container, has been devised for such traffic. Time-saving and labor-saving is accomplished in every operation of handling milk or other liquids by the use of the container car tank. The liquid being placed in the tanks at the proper temperature and the container being properly insulated, the use of ice is eliminated. These tanks may be made as large as required, or as large as may be transferred over the highways.

In actual service all of the containers from the car will be hoisted and placed on a motor truck regularly in about a minute per container. To transfer the same amount of milk between truck and railway car in the standard ten-gallon cans would require over two hours in manual labor.

The cleaning of one of the large 600-gal. containers could be accomplished within five minutes, while it would require fully an hour to clean 60 cans required to carry the same 600 gal. of milk.

Platforms requiring extensive space for handling the 10-gal. milk cans will be done away with. This will greatly facilitate the handling of milk at the unloading platforms, because more cars can be handled in the same space and in less time.

The consumption of milk in large cities has had a steady increase, and of course it is a railroad problem to supply facilities for the handling of milk. As long as the 10-gal. cans are used, each can must be handled individually, but any milk station shipping 600 gal. or more, or multiples of any designated size of tank, could utilize the container car tank service and lessen the handling at the shipping point and at the receiving point.

The limiting feature of a liquid container would simply mean the capacity of the truck for transferring over the highways. The tank can be made to carry in bulk any amount—600, 1,000, 1,500 or more gallons of milk. The capacity depends solely upon the truck.

In the milk containers the glass-lined tank is sealed and locked, and in addition a regulation refrigerator car ice hatch plug is used for insulating purposes. This plug is dropped into the opening, and then the container cover is fastened down and sealed.

May Be Handled on Ships.—An important feature of the container system is its adaptability to water transportation. Containers can be loaded, transferred by rail, and lowered into the hold of a ship without necessity of handling small packages, saving man-power and space.

Let us take, for example, a shipment from China of silk, which is one of the most valuable of commodities, to New York. There is no reason why the container system should not be extend to a shipment of this kind, the container being loaded in China, placed on the boat, unloaded at San Francisco, and transferred by rail to New York with contents not touched. This would permit a shipment of this kind to come by regular freight, secure at all times from tampering or damage, because it is not possible to open the doors without taking the containers off the cars. Such interchange with foreign countries is a possibility of the future.

New York-Buffalo Service.—The container car system of handling less-than-carload freight now in operation regularly between New York and Buffalo and intermediate points, gives "store door to store door" service for less-than-carload freight. All the equipment that is necessary to install the system with utmost saving is a crane for lifting the container to and from the trucks at the shipper's or consignee's plant. The container may be left on the truck and unloaded there, but if there exists lifting facilities it is quicker and cheaper to take the container from the truck and place it on the shipping or receiving platform, releasing the truck for other work while the container is being loaded or unloaded.

The containers are 7 ft. wide, 9 ft. long and 8 ft. high, and they have a carrying capacity of 7,000 lb. This keeps the gross weight within the carrying capacity of a 5-ton truck. The containers are made of steel throughout, except the floors, which are of laminated wood. They are well braced, and there is very little chance of damage with ordinary handling.

"An Engineer's Civilization and a Lawyer's Government"

This apt characterization of the way in which our national government has frequently failed to respond to the genius of the American people fell recently from the lips of Edwin Ludlow, retiring president of the American Institute of Mining and Metallurgical Engineers. If, like most pithy sayings, it cannot be taken with absolute literalness—indeed, Mr. Ludlow's expansion of his thesis showed that he did not intend it to be so taken—yet it contains no small degree of truth. Engineering is dynamic; the law is static. Engineering is in haste to get on the job; the law's delay was ancient in the time of Hamlet. Engineering is for tearing down obstacles; the law is prone to erect them. Engineering tunnels the mountain; the law follows a tortuous path around its base. Engineering is mathematical and is founded on the exact symbols of arithmetic; the law is literary and dwells fondly on commas and diacritical marks.

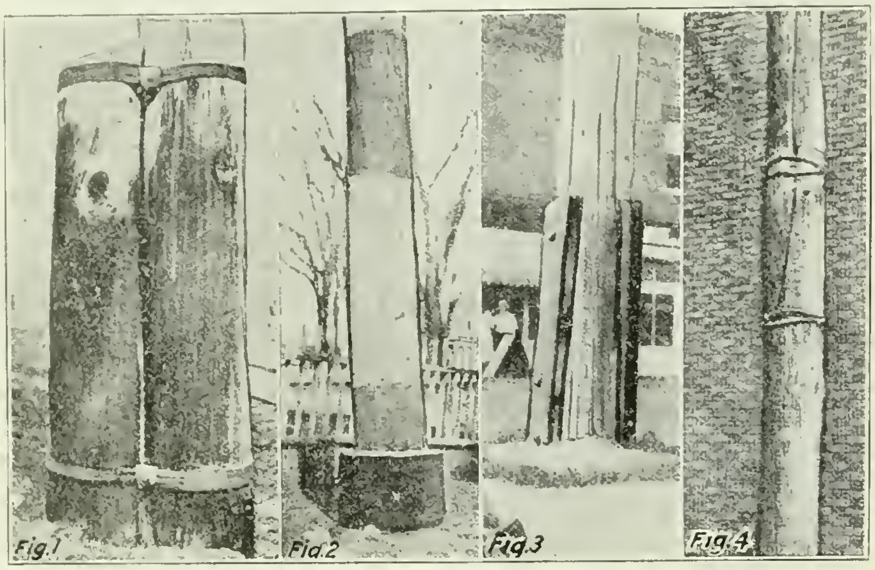
This is a government of laws and not of men, as we are frequently reminded. The law is and must always be supreme. Lawyers, however, are men, and to their hairsplittings and professional hesitations an undue amount of political reverence has sometimes been accorded. Perhaps engineers, as their influence in government increases, will, with their shorter-cut methods, their more practical outlook, their bolder attack and their greater concern for general interests when these clash with particular ones, make the science of government express more fully the national delight in accomplishment as contrasted with debate than the preponderance of legal minds in Congress and Cabinet has made possible in the past. —Editorial in Electrical World.

Brazilian City to extend Street Railways.—Information has reached the Electrical Equipment Division of the Department of Commerce, that the Municipal authorities of the city of S. Luiz do Maranhao, Brazil, are desirous of securing proposals by November 27, for a thirty-year concession to extend the present electric light and power supply and electric tramway system. This city has a population of approximately 53,000.

Nine Methods for Reclamation of Poles

Methods for Reclaiming Poles So Deteriorated as to Otherwise Require Renewal Described in Committee Report At Convention of American Electric Railway Engineering Association

Stub Reinforcement.—Probably the oldest method of reclaiming wood poles and one which has been used to considerable extent by the telephone and telegraph companies and to some extent by electric railway companies, employs the use of a stub set alongside the decayed pole and securely bolted to it. In addition to bolting, a wire wrapping is usually placed around both pole and stub at the top of the stub and near the ground line. The wrapping is then tightened by the use of bolts equipped with clips to hold the wrapping together. This method is shown in Fig. 1. Stub reinforcement should be applied only to poles in straight line sections or corner poles which are properly guyed. This method of reclamation, of course, is limited to use in country districts or on private right-of-way as its unsightliness would prevent its use in city streets.



Figs. 1-4.—Methods of Reclaiming Deteriorated Wood Poles.

Reinforced Concrete.—Several methods have been used, one of the best known being the Orr method, a patented process which consists in scraping off the decayed wood, driving reinforcing rods into the pole so that they reach entirely across the reduced section, placing a cylindrical form about 3 in. greater in diameter than the diameter over the rods and filling with concrete. This should completely cover the rods. A pole reclaimed by this method is shown in Fig. 2. Although this method is rather expensive its use may be justified where there are a large number of wires on the pole. Where the number of wires involved in transfer work is small, it is probably cheaper to replace the pole.

Structural Steel Reinforcing.—A method of reclaiming a pole by the use of heavy channel irons bolted to the pole and concreted below the ground to a depth of about 30 in. is shown in Fig. 3. This method has been used successfully in cases where perfectly sound poles have been struck by automobiles or trucks. The pole shown in the cut was badly damaged by an ambulance and being an important corner in a duplicate circuit transmission line, difficult to cut out of service, this method was applied in preference to replacement which could only have been done at considerable expense.

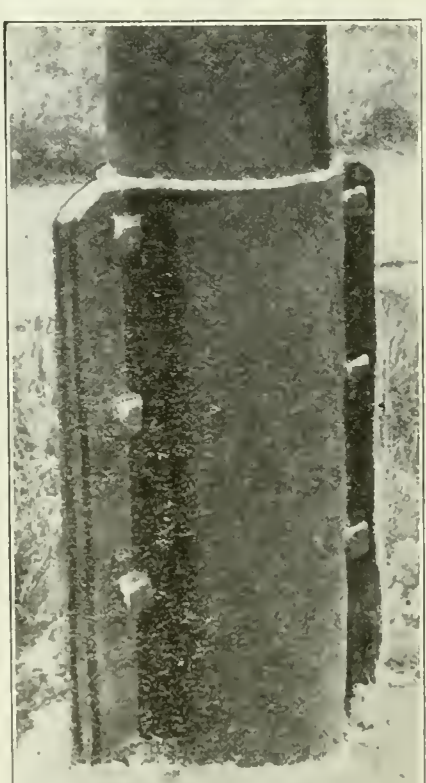


Fig. 5.—Two-Piece Bolted Clamp Method.

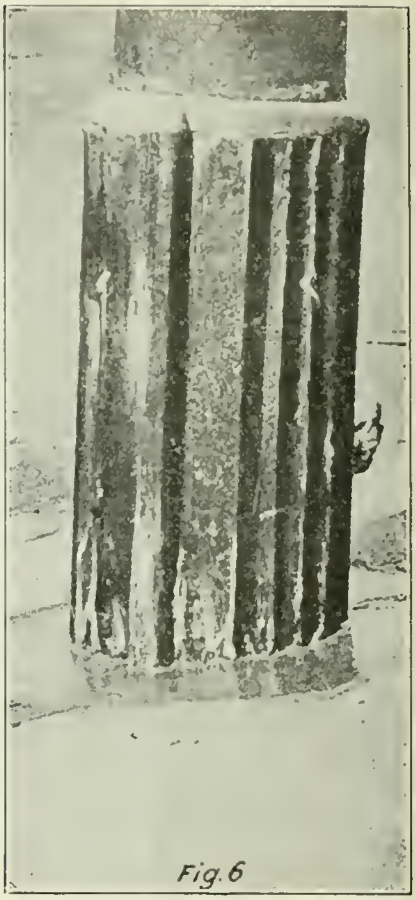


Fig. 6.—Repairs with Drew Split Sleeves.

Splicing.—The use of this method is limited by strength requirements and should only be used where ample strength is secured by a proper guying or close pole spacing. As usually applied, the decayed pole is cut off above the ground line and the butt replaced by a sound one which has been cut at the top to make a good splice and bolted with through bolts. The splice may be wrapped with iron wire to reinforce the splice if so desired. This method is shown in Fig. 4.

Tubular Steel Poles.

Bolted Clamps.—Two-piece bolted clamps have been used with considerable success, one company reporting the use of such clamps for about fifteen years. These clamps may be made in a bulldozer from ⅜ in. steel plates about 30 in. long, to conform to the circumference of the pole with provision for six clamping bolts on each side. In applying this method the joints between the clamps above the ground line should be filled with cement, as shown in Fig. 5, to retard corrosion of the clamping bolts. This method, if properly applied, should extend the life of a tubular pole several years.

Reinforced Concrete.—Some companies have used a method consisting of a cage of reinforcing rods inside the pole with concrete filled in to the required height to give ample strength. The use of a section to tee rail inserted in the pole with concrete has been reported as successful where great strength may be required. Some trouble has been experienced where tubular poles have been filled with concrete on account of water collecting and freezing in cold weather, causing expansion and resulting in cracking the pole. This trouble has been remedied by drilling a small hole near the bottom to permit the escape of water.

Pipe Sleeve.—This method consists of slipping a 24-in. or 30-in. pipe sleeve, of larger diameter than the pole, over the pole and filling the space between the sleeve and the pole at the ground with cement grout or sulphur. Although this method has been found successful, it requires the removal of the fixtures which may be very expensive in some cases. One company reported the reclamation of 1,785 poles by the use of this method during the year 1921 at an average cost of $5.74 each. This method was applied only to poles carrying span wired. Poles carrying heavier strains were reinforced with split sleeves.

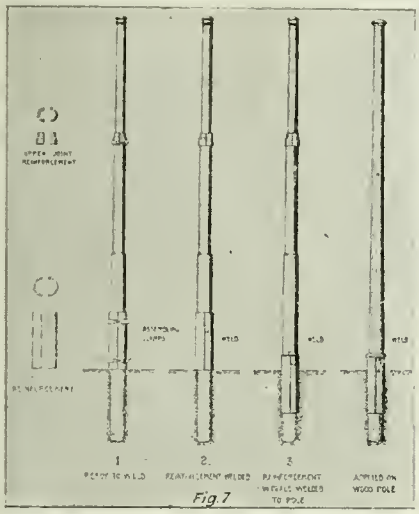


Fig. 7.—Welded Sleeve Repair.

Drew Split Sleeves.—These sleeves (Fig. 6) are cast of malleable iron, ribbed to give greater strength, and provided with special lips that form a lock joint when the pole sleeve is in place. When the sleeve has been placed in its final position the space between the pole and sleeve is filled with cement grout. The Drew Electric & Manufacturing Co. is manufacturer of these sleeves and holds patents on their use. The sleeves can be installed for a fraction of the price of a new pole.

Welded Sleeves.—From information received by the committee, this method (Fig. 7) is also covered by patent. However, the purchase price of the sleeves covers the use of the patent which also permits the use of any type of welding equipment in installation of the sleeves. The method makes use of a split sleeve conforming closely to the circumference of the pole. The sleeve is clamped in place until the weld is completed. Originally, a drop hammer was intended for use in driving the sleeve below the ground line after the weld has been completed. It has been found that the use of the drop hammer can be abandoned on account of the relatively small cost of excavating to the final depth of the sleeve.

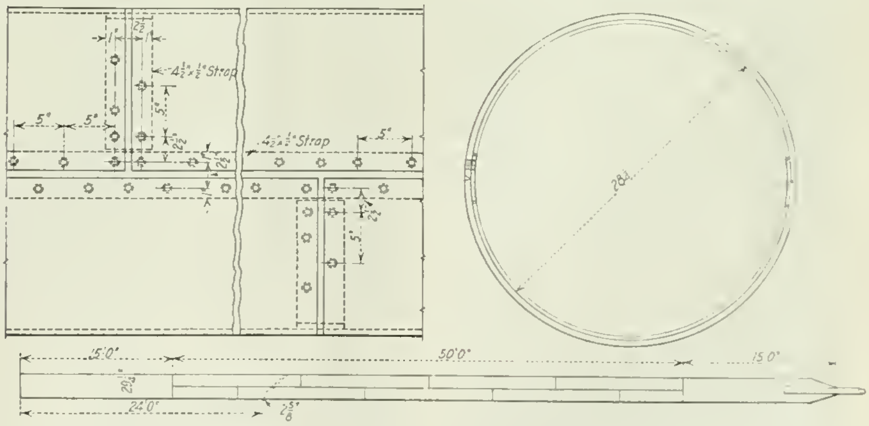
Quarry Blast Breaks Down 83,000 Tons of Stone

A recent blast at the limestone quarry of the Bethlehem Steel Co., which broke down 83,671 tons of stone is described in the September issue of The Hercules Mixer. The shot consisted of 51 well-drilled holes averaging over 80 ft. in depth. A dolly was used, first, for determining the condition of the holes and checking their depth before loading and, second, for tamping the charges and stemming material. Sixty per cent Extra L. F. Hercules was used in the bottom and Hercules Special No. 1 in 4x12-in. cartridges in the top of holes. Until the dynamite charge came above the water level, the cartridges were dropped into the hole without slitting them. After the water level was passed, the cartridges were slit and their contents poured in through large funnels which were placed in the iron pipes used for casing the collars of the holes. In some cases, where the holes were too far below grade they were filled with screenings to give an average depth of the holes of about 8 ft. below the quarry floor. The rope by which the dolly was lowered into the holes was marked at 25, 50, 75, and 100 ft., so that the progress of loading could be judged at any time. To lower the cordeau, a cartridge of 60 per cent Extra L. F. 4-in. x 8-in., was fastened securely to the end of the cordeau and carefully lowered to the bottom of each hole. Then the dolly was let down to determine whether the cordeau had reached the bottom. The cordeau was then cut off about 6 ft. above the top of the hole and securely fastened. Deck loading was employed wherever necessary; that is to say, the explosive charges in the holes were separated by layers of stemming where it was thought advisable. For firing one electric cap was connected to the end of the cordeau and fired by a blasting machine. By this shot 22,000 lb. of dynamite broke down 83,671 tons of limestone, or almost 4 tons of stone per pound of dynamite.

Method of Reinforcing Dredge Spuds

By JAMES H. POLHEMUS,
General Manager, Port of Portland.

The port of Portland owns and operates three 30-in. dredges and one 20-in. dredge, all of which are provided with wooden spuds. The spuds for the 30-in. dredges are 35 in. in diameter and 80 ft. long turned true to size their full length. To prevent chaffing, bars of steel ⅝ in. x 3 in. have been placed in a vertical position around the circumference for about three-fourths of the total length of the spud.



Steel Casings for Spuds of 20-In. Dredge of the Port of Portland.

Due to an increased depth of digging and more severe usage of the dredges, spuds have been broken quite frequently of late, and as the expense incurred by such breakage is very extensive (caused especially by the delay of the dredge) considerable study has been given as to the best method of strengthening the dredge spuds.

After due consideration it was decided to turn the spud down to 34 in. at the middle and provide a steel casing around it for about 50 ft. in length. In making up this casing ½-in. steel plates were used. These plates were properly bevel planed at the seams, rolled to fit the circumference and during the process of welding were held in place tight to the spud by means of heavy clamps made specially for the job.

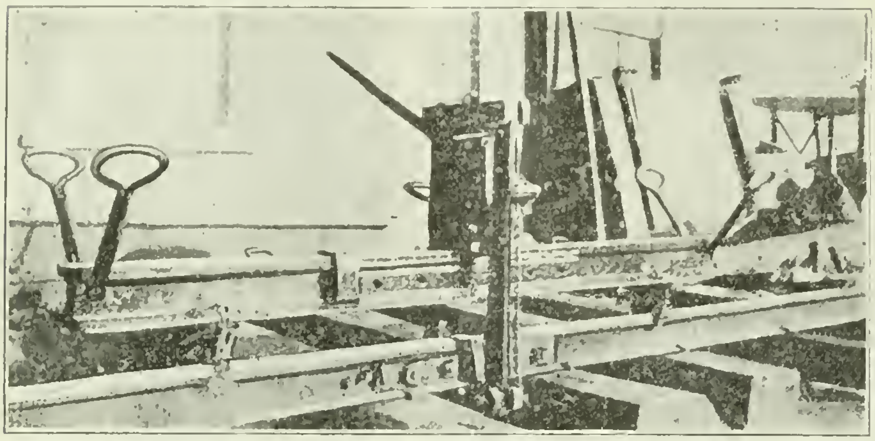
As the Port has had a great deal of experience with electric welding and the strength of welded joints in the past (especially with welded dredge pipe) it did not occur to us that there would be any difficulty in developing the proper strength of the seams in these casings, but upon completion of the first spud it was discovered that our method was not satisfactory. In rolling the spud on the skids the "sag" due to its own weight caused the horizontal seams to crack.

As our first experiment was not a success, another method was decided upon. Butt straps 4½ in. x ½ in. were placed inside the plates at all seams, holes were drilled and tapped for ⅞-in. studs spaced about 5 in. apart. After the studs were properly screwed in, through both plate and butt strap, they were sawed off flush with the outside of casing. After the plates had been properly fastened together with studs all the seams were then electric welded. The last method has proven very satisfactory and all dredge spuds for the Port will hereafter be provided with steel casings.

New Rail Bending Device

A rail bender developed on the Salem Division of the Eastern Massachusetts Street Ry. Co., is illustrated below. The bender takes a more powerful jack to do the work but it is claimed the ease in handling is much greater and the danger of accident much less. The jack (a 35-ton journal) is placed at the center and on top of the bender instead of at the end and underneath. It is bolted to a plate that has been welded to the rail so that it is always in place and there is no danger of its slipping off. If at the end of the day's work, and it is so desired, it is but a few minutes' work to unbolt and remove it. The yoke is self-centering and adjustable to different sections of rail. All pins and loose small parts that are likely to easily get lost are attached to the main parts with chains. The feet, upon which the bender rests, are movable so that one can take care of either a short or long vertical bend, as the case may be. The handles are long, coming to about

8 in. above the head of the rail of which the bender is made, for if they were not so the outfit would be top-heavy with the jack in the position it is. There is also a brace support that slips over the top of the bender and the rail opposite that will prevent the bender from falling over and injuring the men. This particular bender was built of A. S. C. E. 85-lb. T rail, is 7 ft. long and weighs complete 460 lb.



New Rail Bender Developed by Eastern Massachusetts Street Ry. Co. for Use on T-Rail.

Anaylsis of Federal Control of American Railroads

An analysis of the "Federal Control of American Railroads" prepared by Philip G. Otterback, of the Bureau of Railway Economics at Washington, was published on June 1: The Financial Chronicle, of New York, gives the following extract from the analysis:

Mr. Otterback in his memorandum says:

> During the period of Federal control of the American railways (from Jan. 1, 1918, to March 1, 1920) there developed certain unavoidable effects of the general scheme of Government control and certain policies of the United States Railroad Administration that exerted most unfortunate influences upon the transportation system of the country. It is the purpose of this memorandum to deal with the chief of these effects and policies.

As to the unavoidable effects of Government control, Mr. Otterback cites:

> 1. The confusion incident to the change from private operation to Governmental operation.
>
> 2. The fact that appropriations for use in operating the railroads were necessarily made by Congress and hence affected by political considerations.
>
> 3. The loss of much of the normal incentive for economy and efficiency on the part of the subordinate officials and employes, due to the fact that financial losses had to be made up by the Government.
>
> 4. The loss of the advantages due to competition among the railroads.

Concerning these the author says:

> These four effects existed to a greater or less extent throughout the entire period of Federal control, but it can be said that their evil influences terminated practically with the end of Federal operation.
>
> The same statement cannot be made regarding certain efficiency-impairing policies of the Railroad Administration.

In discussing the policies of the Railroad Administration, the efficiency-impairing effect of which did not cease with Federal control, the writer cites the following:

> 1. The change from mere regulation by the Interstate Commerce Commission to actual Federal operation of the roads themselves under Governmental authorities.
>
> 2. The change from individual management of individual roads to management of all roads as a unit from Washington.
>
> 3. The consequent promulgation and enforcement of national orders, which disregarded the variations in local conditions. An illustration of this is the standardization of wages, under which a station master, for example, in a small town in Georgia, received exactly the same pay as a station master in large cities, regardless of difference in living costs, and the like.
>
> Another example is the standardization of rules and working conditions in the shops of railroads everywhere, resulting in excessive costs and reduced efficiency.
>
> Another example is an attempt of standardization of equipment, although the existing equipment had been designed to meet purely local conditions of rail weight, strength of structure, grades, etc.
>
> 4. On the financial side the disregard of maintaining proper relationship between income and outgo, leaving enormous deficits to be made up by taxation and leaving upon the railroads, when they were returned to private control, the necessity of rate increases which should have been made at a much earlier period.
>
> 5. The scattering of freight car equipment about the country regardless of its ownership and to a large extent in disregard of the character of work for which particular cars were designed.
>
> All of this involved enormous movement of empty cars after Federal control and a highly abnormal number of cars in bad order. At the beginning of Federal control 44 per cent of the freight cars were on their home lines and at the termination of Federal control only 22 per cent were on their home lines. Cars on foreign lines are not kept in as good repair as cars on home lines.
>
> 6. The maintenance policy in regard to both way and structure and equipment. For example: Not only were tie renewals in 1918-1919 below the average of tie renewals during the test period, but they were also of a lower grade. The same applies to ballast and the same policy ran through the whole physical structure of the roads to a greater or less degree.
>
> 7. The failure of the Railroad Administration to provide necessary additions to the railway plant—cars, engines and trackage and terminal facilities.
>
> 8. The demoralizing labor policy. For example: As a heritage of Federal control, the railroads, instead of dealing with their own employes, were forced to deal on a national basis with the heads of national unions, with the resultant loss of discipline and efficiency in railway forces. There was an atmosphere of disruption and disorganization from which the railroads have not even yet fully recovered.
>
> 9. The withholding of money due to individual roads after Federal control was over.

The writer goes on to say:

> Practically all of these policies, as such, are now discontinued, but their baneful effects upon the transportation industry are still felt.
>
> Due to the foregoing effects and policies, there developed a general weakening of railway credit and of railway securities which in turn had an additional depressing effect upon the efficiency of railway operation.
>
> This memorandum is not intended at all as a criticism of the United States Railroad Administration, as many of its policies were determined to practically the last degree by the exigencies of the national and international military and economic situations, and many of these same policies, in perhaps a somewhat less radical degree, might have been forced upon the railways under private operation. None the less, these expense-breeding and efficiency-impairing policies were adopted during the period of Federal control and must be faced as matters of fact.

Personals.

A. J. Hammond has joined the organization of James O. Heyworth, engineer and general contractor, 606 South Michigan Ave., Chicago.

F. D. Lakin, division engineer of the Meadville division of the Erie System, has been appointed acting regional engineer, with headquarters at Youngstown, O. He succeeds H. Knight.

Walter S. McKee has resigned as Vice-President and Director of the American Manganese Steel Company and will develop the business of the Inland Engineering Co., 28 East Jackson Blvd., Chicago, of which he is President.

A. L. Grandy, heretofore chief engineer of the Pere Marquette R. R., has been appointed to the newly created position of assistant to the president and general manager of the Pere Marquette. H. A. Cassil, who has been engineer of maintenance of way, becomes chief engineer.

C. M. Osborn, formerly city manager of East Cleveland, O., has entered upon his duties as city manager of Kenosha, Wis. Mr. Osborn is president of the National Association of City Managers. He is a graduate of the Case School of Applied Science, where he was an honor student. He was later city engineer of Lorain, O.

Weston E. Fuller has withdrawn his membership in the firm of Hazen, Whipple & Fuller, civil engineers, 30 East 42nd St., New York, to become professor of civil engineering in Swarthmore College. The firm name is changed accordingly, and again becomes Hazen & Whipple, which was the name of the firm from 1904 to 1914, inclusive. All the other partners remain, and business will be conducted as usual.

Dr. Samuel Wesley Stratton, for 21 years director of the Bureau of Standards at Washington, has been elected President of the Massachusetts Institute of Technology. He will assume the position on Jan. 1. Dr. Stratton was born in Litchfield, Ill., in 1861, and was graduated in 1884 from the University of Illinois, where he later became Professor of Physics and Electrical Engineering. From 1892 to 1901 he was with the physics department of the University of Chicago. As head of the Bureau of Standards he has built up from a small office of weights and measures employing three or four persons, a bureau which occupies a dozen buildings and has a staff of more than 900 employes.

Buildings and Structural Issue

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(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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The Significance of the Building Material Price Rise of 20 Per Cent in 12 Months

A year ago in September, according to the Bureau of Labor, the wholesale price index of building materials was 160, whereas this September it was 180, a rise of 20 per cent in 12 months. The price index, or price level, was 100 in the year 1913, so that building material prices now average 80 per cent above the pre-war level, and they bid fair to go higher.

In August the building material price index was 172, hence the rise was 8 points in one month. Now that winter is approaching, there may be a cessation of this price rise in the building field, but it is our belief that the rise will be resumed next spring.

During the past three years the editor has published several forecasts of the probable movement of commodity prices, and in each instance has been substantially correct. These forecasts have been based on the theory that the two dominant factors that control wage levels are the per capita money and its velocity of circulation or rate of turnover. In June, 1920, per capita money began to decrease, because federal reserve notes began to be called in. Coincidentally bank clearings began to decline, indicating a decrease in the rate of money turnover, and average wholesale prices began to fall. The bottom of this wholesale price level was reached in January, 1922, since which the wholesale price index of 400 commodities has risen 13 points, or 9 per cent. Had food products kept pace with other commodities in the rise, a much greater average increase in the price level would have occurred. But a falling off in European demand for our foodstuffs has caused a glutting of the American markets, resulting in abnormally lowering the price of grain, meat, etc. In September, farm products averaged only 33 per cent in price above the average in the year 1913, and foods averaged only 38 per cent above the 1913 level. Since these two classes of commodities form 40 per cent of the total of all commodities in the Bureau of Labor index, it is evident that their relatively low price accounts for the fact the general price level is not considerably higher than it is.

It is reasonably certain either that the farmers will curtail their production next year, as many farm periodicals are urging them to do, or that Eupropean markets will again be restored to them through tariff changes that will permit the inflow of European goods with which to buy our farm products. In either case, farm products will probably rise in price, next year, and farm prosperity will be restored. Such a restoration will increase general prosperity, causing both an increase in federal reserve notes (i. e. paper money) and the rate of money turnover, thus bringing about a general rise in prices, in which building materials will share.

Our per capita gold is 80 per cent above that in 1913, and is increasing at the rate of 8 per cent yearly. This 80 per cent increase is alone sufficient to cause an 80 per cent increase in wages above the level of 1913, and unless the efficiency of workers has increased since 1913, commodity prices are destined soon to average 80 per cent above the pre-war level.

Prof. Charles J. Bullock, Chairman of the Harvard Committee on Economic Research, has just announced that that committee has come to the conclusion that there will be no drop in the American commodity price level for 10 years. He cites the great increase in our gold holdings as the main reason for this forecast. So far as wage levels are concerned we are in agreement with this conclusion, but Prof. Bullock has ignored one important factor in estimating price levels, namely per capita efficiency of production. However, during the most progressive decade of our history (1869 to 1879) per capita efficiency of production increased 25 per cent. If this productivity record were to be equalled in the next ten years, its effect would be to lower the price level 20 per cent, were all other factors to remain unchanged. But there is strong probability that change in other factors will more than offset increased productivity in its effect on price levels, namely increase in per capita money. With the great nations of the world indebted to this nation to the extent of more than $10,000,000,000, it is probable that most of the $150,000,000 of gold produced annually will flow into America for at least another decade. If only two-thirds of this new gold reaches us, it will add 3 per cent annually to our gold reserves, and since our population is growing at a rate of slightly more than 1.2 per cent annually, the influx of new gold would raise our per capita gold about as rapidly as the best probable increase in per capita productivity would tend to lower the price level.

In addition to increase in per capita gold, there probably will occur an even faster increase in our paper money. Recent English experience has taught our bankers that they can operate with lower gold reserves than have hitherto been regarded as safe. This will probably lead to greater bank credit expansion in America than would once have been deemed safe, and this will mean a greater relative issue of federal reserve notes (paper money), with a consequent rise in both price and wage levels.

Steel and copper prices are far below what they will probably be a year or so hence. In September the price index for metals was 134, or only 34 per cent above the 1913 level. When the price level for metals rises to 180, it will have risen 46 points, or 35 per cent above the September level. Any builder who expects to use much steel should not defer ordering it well in advance.

The price and wage level formulas deduced by the editor, and referred to above, accord closely with past history for more than half a century. Hence forecasts based upon them are much more likely to be correct than forecasts based on other lines of reasoning.

Reconstructionand Remodelling

Let owner, architect and constructor vie as they will in damning a reconstruction job for its annoyances, at the very least each is at it for financial profit. But even the prospect of profit is not always sufficient to overcome an owner's aversion to annoyance or an architect's desire for original accomplishment, and so an old building which might have been made to serve usefully is pulled down to make room for a new one, which can only be an expensive luxury.

This tendency is prevalent in the United States today, though of course there are other influences contributing to it—personal and civic pride of owners for example. While we certainly do not condemn either public spirit or the desire for accomplishment, it is not always the most showy construction which best serves public interest or marks the most praiseworthy accomplishment.

We know a western city with two principal business streets, each conspicuous for its large number of antiquated and decrepit buildings. Among the one, two and three story relics of an earlier day, and the taller ramshackle structures, are a few substantial five and six story buildings, of which last, two have been pulled down within recent years to make room for the strictly modern. One of these was dismantled just in time for its successor to meet a year's delay in getting steel and a tremendous increase in cost due to the war. We doubt if even under more favorable circumstances the change would have been profitable. As it was, the venture was a costly one, and only strong financial backing saved it from failure.

The second project turned out worse. It involved the tearing down of one of the best of the old six story structures, and its replacement with fourteen stories of modern Class A construction. About eight stories of the skeleton were up when financial ruin overtook the promotors, and in the two years since not a stroke has been done upon it, although there have been several attempts to get it completed and into service for one purpose or another.

Now the folly of these cases lies not in the desire to improve, or to do something worth while, but rather in the destruction of good, income-producing property in a city having an abundance of inferior property and no rapidly expanding needs. In fact, modern buildings previously erected without the razing of any of the better of the old structures had not been financial successes; and in at least one case it had been impossible to charge sufficient rentals to avoid a mortgage foreclosure.

It is true enough that old buildings structurally sound often are unsuited in detail and arrangement to the requirements of modern business, but judicious remodelling will generally put them into thoroughly usable shape, and the destruction of such can only be justified by much enhanced land values or by requirements of special circumstances.

Whether or not an old building should be replaced by a better is a question which can be answered with mathematical accuracy when the data of the case are known; and intelligent recognition of this fact would go far to secure right decisions either for or against new building projects. Probably the commonest deterrent to the use of the mathematical guide is the fact that some of the factors are usually not determinable. Such objection, however, is not well grounded, for even where factors must be guessed at, the guesses on elementary and independent factors are likely to be far nearer correct than is a single guess on the project as a whole, or a series of guesses not combined on mathematical rules. Still more valuable is the determination of the limits of the case by calculations with factors at the extremes of what might reasonably occur. When this is done, the values of the project under either the worst or the best conditions are foretold, and even though the results are not always conclusive, such judgment as remains to be exercised has received a maximum of guidance.

Undeniably some exceedingly creditable reconstruction and remodelling work has been done by both architects and constructors; and ingenious means have been devised for its accomplishment. Nevertheless we believe that great improvements are possible, and that a greater appreciation of the economic value of such work will lead to their development. It is by no means every old building that will stand remodelling, and the decision called for is sometimes not between remodelling and new construction but between remodelling and letting the old structure stand with bare maintenance.

We believe that opportunities for advantageous remodelling and reconstruction are constantly being overlooked, and that the field may well receive more attention than it has had. Perhaps not the least of the difficulties to be overcome is the mental aversion with which it is apt to be approached. A little more broadly philosophical attitude would bring an acceptance of the circumstances as merely reasonable and proper features of each man's work.

"Do Engineers Think?"

To the Editor: I have been impressed during the past few years more than before, although it has been a matter for thought for years, with the apparently few among those calling themselves engineers who have any desire to be such.

The students at one of our engineer colleges a year or two ago were up in arms over the debate of the subject, "Do Students Think?" Where would a like debate bring us with the subject changed to the topic, "Do Engineers Think"? Go into a group of engineers anywhere and ask a question on public matters of almost any sort, and note the replies.

How many of the engineers ever rise to the position which should by right belong to an engineer? How many of them fail because they make not the slightest attempt to fit themselves for such positions? And what is the matter with the engineer?

A Chicago banker was asked why he gave certain appraisal work to an accountant, when the work required an engineer. He replied that the accountant gave him a report which was understandable, and definite. He showed a report by an engineer which did not, to his mind, give such information.

An engineer of wide practice had occasion to use seven assistants on an appraisal job. He placed a request for that number of men with an engineering association which has an employment department. Of the seven men sent him, five were not qualified for the work, and were sent back. Railroad fare alone was over $28 for each. Does an engineer think when he seeks a job which he does not feel sure he can fill?

Does an engineer think when he gives an opinion on a labor question, for instance, when he has no real knowledge upon the subject? An engineer has but one claim to employment, and that is that in some one or more lines he is better informed than any other except an engineer. The average employer may not be well informed upon this question, but if he hears the engineer give a ready answer to some question to which the employer has given much thought, and the answer shows a lack of understanding of the question, will the employer have a high opinion of that engineer?

A year ago the writer attempted to start and conduct a class in railroad economics. Although the fact is apparent that there is a great demand for economists, and that their pay is liberal, it was impossible to interest a dozen members out of an association of engineers with a local membership of over 1,600.

At the present time one of the mightiest questions which is facing the railroad managers of the country is the matter of moving the traffic more economically. Even in the American Railway Engineering Association there appears to be only a negligible percentage who have even a superficial understanding of the subject. It is commonly thought to lie between easier gradients and heavier motive power. Glib-tongued salesmen descant upon the benefits of heavier power. Do the results bear out the salesman's contentions? It is easy to determine the cost of 50 new engines of a heavy type on the one hand and of certain grade reductions on the other. But is this all? The new type of engine may call for heavier rail, stronger bridges, increased depth of ballast, longer turntables, deeper roundhouses, higher opening in the water tanks and many other alterations.

But when all of this is done and all these expenses have been met has the question been settled? Is it by any means certain that on all roads the heavier engine brings economy? It is admitted, say, that the engine will move in a train 30 per cent more tonnage than the superseded type would. But will it cover the trip in the same hours and will it go as long between periods in the shop as the old type? The engineer should keep a vision over the period between the periods of "rebuilding" in the shops. How long will it be with each class and how long will the period of idleness take?

And is not somewhere around 97½ per cent of the fault for this with the employer? In my 36 years' service with various railroads, I never knew a superior to inquire if the subordinate read engineering books or papers or studied questions of operation. I never knew this to be taken into consideration in making promotions. The matter of seniority and the matter of personal influence were all that were considered.

If an employe is sure of a steady promotion without regard to his fitness, will there be any inducement for him to become fit? Would it not bring rich returns to the chief engineer who would call for semi-annual reports from each employe as to what he has read during that period, what meetings he has attended, what new works of any kind he has visited and annually arrange a trip over some part of the system, or a neighborhood system? Make it a minimum requirement to remain in service that he should read four new books each year on engineering subjects and should read at least one weekly publication on his specialty and belong to at least one association working along engineering lines.

A. M. VANAUKEN.

Chicago, Ill.

Will the Engineer Supersede the Architect?

Editorial in The Architectural Forum, October, 1922.

The past few years have seen developments in the professional service of designing buildings that make it natural to wonder if the architectural profession is advancing or losing ground. Certainly there is ample evidence, especially in the East, that the field of practice for engineers and engineering-contracting organizations is constantly widening and embracing types of building that were formerly considered the architect's undisputed province. The growth of building practice among engineers came about in the last decade, or more primarily because of our large industrial development and the increasing use of reinforced concrete for the buildings needed for using it. Reinforced concrete presented a problem well suited to the engineer, and industrial building was nothing more than the enclosing of certain volumes of space with the type of construction most efficient from both cost and maintenance viewpoints.

Following the war there occurred a decided slump in industrial building, and engineering organizations that had been operating in a large way with expensive overhead costs were obliged to find other fields or go out of business. It was but natural for them to turn to office, bank and other commercial buildings that were in demand. In some instances they have not hesitated to solict commissions for educational and institutional buildings. The fact that they have in many cases been successful in securing this work does credit to their business acumen, but it proves distinctly that the architect has not made the value of his service known to the public.

When one considers comparisons between architecture and structural engineering it is well to admit at once that engineers can construct fully as well and in many cases better than architects. Structure is their chief concern, and their knowledge of the strength of materials and the forces at work in a structure is superior to that of architects. The realization of this through their contact with architects has made it seem to them that they possess the strongest asset in the requirements for practice, and that it would be comparatively easy to supply the apparent part played by the architect in the design by adding to their organization a group of architectural designers. They have secured their opportunities to build by means of good, direct salesmanship—a factor in modern business that the architect has shrunk from adopting because it necessarily means self-appraisal of one's value.

The points on which the engineers can and do claim superiority to many architects are just the features of a building operation that are obviously understood by a client and have, therefore, his immediate interest. He knows that there is a difference between good and bad construction, he knows that there is a difference in cost between different materials; he realizes that good superintendence will insure a better building; he knows that businesslike methods in following contracts and payments will avoid losses, and these are the points of service stressed by the engineer.

Unfortunately for the architect, the value of his services lies along lines that cannot be so readily measured, and the client has little or no appreciation of them. He doesn't realize sufficiently that his building is a vital part of the business, institution, or whatever is housed within it, requiring a distinct, and individual plan to fit the particular needs. This is where the architect's service is superior to the engineer's, and it is the root of all successful building. The various advantages the engineer offers can be provided by any architect capable of creating an organization or intelligent enough to secure expert advice when needed, but the fundamental requirement for good building—the ability to plan—belongs to the architect, and it is something that does not function well in an employe.

Blame cannot be placed on the engineers; they have developed their service openly and they have in the majority of cases provided their clients with buildings that compare with their expectations. The field is open to any and all who can serve it. The difficulty is one that the architects must meet themselves; they must decide if architecture as it is practiced today is to become separated from the business world and employed only in the case of monumental buildings or special work for wealthy individuals where art is the prime consideration and business principles do not count.

It is assumed that any individual or firm practicing architecture must provide all that the engineer does and more, and with this fact capable of proof, serious efforts must be made to show the public wherein the architect's service has special value and why such service can be supplied only by an architect. This message can be conveyed to the public through regularly organized effort of architectural societies and by the individual architect, not necessarily by printed advertising in the case of the individual, but by showing no hesitancy in meeting the engineer in open competition and by presenting his claim for consideration in a businesslike manner that is understandable to the average man. Considerations of beauty will always be paramount with architects, but these are difficult of explanation to the public, and when the architect lays greatest stress on this phase of his client's problem, he opens the way for others to approach and make capital of the points he has left uncovered.

Construction Possibilities with Light Concrete

Editorial in The Canadian Engineer.

Reference was made in our issue of August 15 to the valuable pioneer work done in France by Col. Rabut in applying to the construction of many and varied works concrete made with slag as the coarse aggregate. Finished material having a weight from 30 to 40 per cent less than that of gravel concrete developed in most cases equal to that of the heavier material and made possible the construction of bolder works than had heretofore been practicable in the latter.

Much experimental work of this kind has been carried out in America and the development of light structures in concrete has been shown to have considerable possibilities. One of the departures made was in the use of "bloated" brick prepared by burning clay or shale so that it expanded to several times its original size through the imprisonment of generated gases. The material has a weight slightly over 100 lb. per cubic foot, and concrete of 1:6 mix gives a strength somewhat higher than that given by a concrete with crushed limestone aggregate. Successful application of this light concrete has been made in a number of cases, although the cost per cu. yd. entailed through the patented process of preparing the aggregate is considerably more than for concrete with stone or gravel aggregate.

Experience with slag in America has not led to any uniform advocacy of light-weight concrete made with this material. Excess sulphur may bring about the disintegration of the material and the advisability of exposing it to dampness, especially in their sections, is questioned. There is, too, the fact that only in certain regions is slag readily available at a moderate price.

Engineers will welcome the development of reliable moulded material of substantially less weight than the concretes usually employed. The construction of long-span arches, where the dead weight is of much greater importance than the live load, will be greatly facilitated by the provision of a light, strong concrete. In fact, in any engineering structure where the stress due to weight are an important factor, such a material would be to the great advantage both of the engineering profession and of the client who pays for the work.

An Advance in the Price of Rails

Editorial in the Railway Age.

For over 20 years the marketing of steel rails in the United States has been governed by selling prices that have been established by fiat rather than the untrammeled operation of the law of supply and demand. For this reason, when any change is made in the established base price, such as the $3 advance which goes into effect on October 1, the question arises as to the factors which govern such modifications. For the first eight years after the fixing of $30 as the base price for open-hearth rails, the current quotations of steel beams and plates averaged about 18 per cent higher than those for rails. During the next seven years, when plates and shapes were on a generally lower level, no adjustment was made in the price of rails, but during the period of fixed prices in 1918, 1919 and 1920, recognition was given to a differential between the prices for rails and those for shapes and plates in establishing prices for the latter that were definitely higher than those for rails. With the depression which followed the boom of 1920, quotations for structural materials fell from approximately $70 a ton to about $30 a ton early in the present year. In the meantime, two cuts in the base price for rails, reduced the latter from $57 to $40. The fact that rails have been quoted at considerably more than the structural material during the last 12 months has been taken as indicating the effect of price stabilization; that $40 represented a base price which would not fluctuate while the quotations on other materials ranged above and below this. It now appears, that this assumption was not correct, for no sooner has the current price of structural material advanced so as to equal that for rails than the price for the latter is also advanced. This increase, however, will be purely nominal as regards those railroads which place orders within the next week for their requirements for the early part of 1923.

Present Trends in Engineering Education

Abstract of Address Before Engineers' Club of Philadelphia

By ARTHUR W. GREENE, JR.

Dean of Engineering, Princeton University.

Engineering education at present is marked by several characteristics. The war has shown the advantage of education through the wonderful records made by educated men, and the colleges of the United States have larger enrollments at present than ever before in their history. In many institutions there is a tendency to eliminate certain technical courses of a highly special nature and replace these by courses dealing with Economics, Finance, Business Administration, History, Civics and Hygiene. There is a tendency to reduce the amount of Foreign Language study and to increase the study of English. One other trend is to make the engineering school of greater value to the graduate engineer by offering special courses at particular times during the year. These changes will be discussed in detail.

The tendency to stress fundamentals and to eliminate the more technical courses has resulted in a number of institutions giving common courses to all engineering students for one, two, or even three years and at the University of Iowa the engineering courses are the same for the first three years, and in the fourth year there is only a difference in about one-half of the work. The underlying thought is that as engineering in all its branches has primarily the same fundamentals these should be thoroughly taught to all men and the fundamental subjects which are necessary for the different kinds of engineering can be covered in one-half of the Senior year. Few institutions have gone so far as this, but a common Freshman year is quite prevalent among the engineering schools of the United States.

Co-operative courses to give the student a more intimate knowledge of manufacturing processes have been increased during the last few years, the Massachusetts Institute of Technology being one of the last institutions to offer such a course. A number of institutions are requiring one or two summers in work in industries before granting a degree. Johns Hopkins University requires six months of practical experience in some plant before a man is ready to graduate. At the Rensselaer Polytechnic Institute the Electrical Engineering men replace their second summer shop period by work during the summer in some approved plant.

In order to make the engineering work of greater value, many institutions have introduced preliminary courses in the early years in which the student is brought in contact with the aims, purposes and work of the engineer. These courses are intended to furnish an incentive for better work in those subjects which are necessary for the engineer, but which at first have no practical application.

During the early part of the engineering course other institutions have been guided by the experience at Camp Humphrey and have introduced the problem method in connection with instruction and theory. Tufts College has rearranged its curriculum entirely, giving in the Freshman year an introductory course which takes a large portion of the Freshman year, three laboratory periods and three recitation periods a week. The Civil Engineering students have four projects during the year: a wooden garage, a steel garage, a highway bridge and an underground tunnel. These projects cover Mathematics, Elementary Structural work, Surveying and Drawing and serve to give the student engineering experience in the early part of his course.

The work for the graduate in practice is exemplified by the spring course offered by Professor Ketchum at the University of Pennsylvania for highway engineers. This course of a few weeks' duration is carried on by experts in highway engineering and aid the graduate who is interested in this type of engineering to gain that experience which such a course alone can give.

At Pennsylvania State College a summer course in Industrial Engineering for graduate engineers is given each year.

The demand of commerce and business for men with engineering training has led a number of institutions to give special courses for men who plan to enter business. At Iowa State College a course in Business Engineering has been introduced, while at the University of Washington courses in Commercial Mechanical Engineering and Commercial Electrical Engineering are offered.

At Union College the students in Civil Engineering may choose from a technical option or an administrative option in the later years of their course.

In conclusion, I will again mention the main trends in engineering education: the elimination of highly special courses; the stressing of better preparation in fundamentals; the addition of courses in economics and business and in human relations; the introduction of problems by some institutions; the requirement of work in the industries before graduation and the increase in the study of English.

Inundated Sand Investigation

Considerable progress has been made in this investigation by the U. S. Bureau of Standards. The latest work has for its object the determination of the properties of sand by inundation tests. The determinations of the sand volumes by measuring the sand inundated have been completed. From the tests made, it would appear that the condition of the sand, dry, damp, or wet, has made but a slight difference in the weight of dry sand per unit volume for a given method of placing the sand in the measure. The first set of concretes to determine the consistency of strength, when the sand is measured inundated, has been made. In making up these concretes, studies are being made of the slump, flow, density, and yield. Considerable attention has been given to the study of criteria for determining from the sieve analysis the density of a mixed sand. A few tests have been based on the results of the study, and the data conformed very closely to the curves given by Flaret.

Measuring Vibrations in Buildings

Precise and Approximate Methods Including Description of Special Vibrometer Designed By the Author

By C. R. YOUNG,
Associate Professor of Structural Engineering, University of Toronto.

With increasing frequency engineers are being called upon to deal with the troublesome problem of vibration in buildings. Annoying tremors are brought about, sometimes by machinery in buildings, and sometimes by street or railway traffic. In many instances they have brought about the institution of litigation by the occupants of buildings affected against the owners of the offending machinery or the municipality or transportation company responsible for the disturbing traffic.

Some years ago, in the hope of contributing something to the solution of the problem, the Aberthaw Construction Co., Boston, prepared a short monograph on the subject. This was to constitute a preliminary report, the theoretical analysis, weighing of evidence and discussion of experimental observations being left for a final report, which, so far as the writer is aware, has never been published. In their study, the authors of the preliminary report sought the opinion of a large number of professional men and manufacturers, but only about one-third of the replies received were really informative. Very little or a definite or quantitative character has been published in English on the subject, and until a thorough and systematic experimental study has been made, the enunciation of definite laws will be impossible. However, sufficient experimental work has been carried out to indicate the methods of research that are likely to prove adequate for the task.

Precise Measurements.—In the precise measurement of vibrations of buildings, valuable work has been done by Maurice Deutsch, of New York, and Prof. Elmer E. Hall, of the University of California. Three-component vibration recorders modeled on the principle of the seismograph have been developed by them capable of recording vibrations of much higher frequency than those occurring during an earthquake. Both the amplitude and frequency of each of the three components are indicated by a wavy line drawn by a writing lever traveling on a rotating drum covered with smoked paper.

So many possible causes of vibration in a typical building are found to exist that precise measurements are needed to determine the relative importance of the several active agencies. Records made by Mr. Deutsch and by Prof. Hall show in many cases as many as three distinct disturbances, the evidences of the smaller ones consisting of small waves superimposed on the larger ones of the graphical record.

Frequently, street disturbances are found to produce much larger effects than those originating within a building and forming, perhaps, the original cause of the investigation. Thus, in a characteristic case, Prof. Hall reported (Electrical World, July 27, 1912) that the vibration produced in a reinforced concrete substation in San Francisco by a load of crushed stone passing over a cobblestone pavement in the adjoining street produced vertical vibrations with an amplitude seven times that produced by a motor generator within the building.

An interesting peculiarity of vibration phenomena is that the vibration in a building adjacent to the one housing the disturbance may be greater than in the containing structure. Thus the vibration in a detached 3-story brick building adjoining the substation mentioned above, but not structurally connected with it, was actually greater due to the generator than at a point close to the latter. This circumstance is stated by Prof. Hall to arise from the fact that when a definite amount of energy in the form of a train of waves passes from a structure of dense material into ground, foundations and walls possessing a lower coefficient of elasticity, the amplitude of the vibrations necessary to take up this energy will be greater than in the structure of origin. If the conditions be reversed the results will be reversed accordingly.

Enquiry is sometimes made concerning the probable effect of placing the walls of a building in contact with those of a building containing a disturbance. Experimental evidence at hand is not conclusive, but does not appear to indicate any untoward results. In another instance, Prof. Hall reports in the Electrical World, Dec. 18, 1915, that in the basement of a nine-story steel building with foundation walls in contact with those of a power house, the vibrations were only one-half to two-thirds as great as in the basement of the power house. Possibly the interposition of a vertical layer of soil between the two foundation walls might not have had any benefit further than the slight one of removing the second building a little farther from the source of disturbance.

On the other hand, there is some ground for the view that direct contact of a wall with the wall of a building containing a disturbance may facilitate the transmission of vibration to the secondary building. This would be in accordance with the principle of transmission observed when a metal object is held against a machine to judge the vibration therein. Conceivably, the presence of soil between adjoining foundation walls might lessen vibration in the secondary building in the same manner that a cushioning of felt or rubber under machines on upper floors reduces vibration effects in the supporting structure. Such a material, so far as vibration is concerned, apparently partially insulates the building, due to its density being less than the density of the materials in the floors and walls This is a matter requiring for elucidation definite and systematic experimental investigation.

Approximate Method of Measuring Vibrations.—Reference in Egineering and Contracting, June 28, 1922, to the indication of the extent of vibration in a building by observing the movement of a ray of light reflected on a ceiling from a basin of mercury, suggests a similar method adopted by the present writer in a threatened litigation some two years ago.

The owner of a residence in Toronto built in contact with a machine shop, after the erection of the latter, brought action on the ground that the vibration and noise produced by the operations in the plant were a nuisance. The writer was asked to investigate the matter, and not having the use of a precise instrument of the seismograph type, developed the rough piece of apparatus shown in Fig. 1, which served the purpose of the enquiry very well. With it, it was possible to determine the relative amplitude of the vibration in the house when the plant was running and when it was not running.

The special vibrometer constructed consisted of a wooden frame resting on three coil springs and carrying two longitudinal adjustable banjo strings. The wooden side pieces were 1 in. in diameter, 5 in. apart and about 33 in. long. On the two strings, which were 1¼ in. apart, was placed a porcelain tray containing a 1⅜ in. disk of mercury. The support of the mercury tray was, by reason of the construction adopted, exceedingly unstable and very slight disturbances of the floor or table on which the device rested produced a pronounced quaking of the mercury.

To gauge the amount of this movement, five threads (three only shown in the sketch) were stretched 1/16 in. apart tightly across from one side piece to the other, and at right angles thereto, immediately above the mercury disk. A narrow streak of light was projected from a box with a vertical knife cut in one side onto the face of the mercury in such a way that the observer seated at the side of the instrument and opposite its center would see a thin line of light directly under the central thread and almost hidden by it when the mercury was quiet.

When vibration is set up in the instrument, the reflected line of light curves rapidly and markedly first in one direction and then the other, forming practically a lenticular area of light, as shown in the sketch. The width is gauged by noting the right and left limits reached by the line of light as indicated by the scale consisting of the parallel threads. The observer may then readily determine the maximum bowing of the line of light on one side of the central position and take readings of it in sixteenths of an inch or fractions thereof. One of these divisions was for simplicity designated as 1, and readings recorded as 1, 1.5, etc. The progress of the vibration may thus be watched continuously and the relative effects of given disturbances as identified by the noise produced by them or by pre-arranged signals, may be ascertained. In this regard the method adopted has an advantage over taking a few isolated photographs of an area of reflected light.

The instrument was generally placed for use on a small table, preferably always the same table. The interposition of the table between the floor and the instrument is an advantage, in that it increases the sensitiveness of the latter.

Observations.—Some useful comparative facts were ascertained with the aid of this instrument in the alleged nuisance case cited.

The device was set up on a table on the ground floor of the house adjoining the machine shop and the ruling maximum reading with the plant running and no other disturbance existing nearby was found to be 1. On four occasions, during a continuous observation period of 1¼ hours, the reading increased to 1.5 or 2.0 due to motor vehicles passing along the street outside, due to the passing of a freight train on the adjacent railway track, or due to a large lathe cutting a casting accompanied by a characteristic loud "growling" noise. Without the cumulative effect of motor or railway traffic in the immediate neighborhood, the maximum disturbance in the house created by operations within the plant was represented by the reading 1.5 and this occurred only twice in 1¼ hours and for periods of only two or three minutes each. The reading 2 arose only when trains were passing.

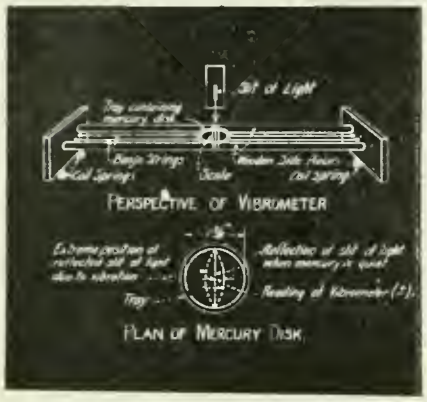

Slit of Light
Tray containing mercury disk
Banjo Strings
Wooden Side Pieces
Coil Springs
Scale
Coil Spring
PERSPECTIVE OF VIBROMETER
Extreme position of reflected slit of light due to vibration
Reflection of slit of light when mercury is quiet
Tray
Reading of Vibrometer (2).
PLAN OF MERCURY DISK

Fig. 1.—Special Vibrometer.

On a Saturday afternoon with the plant mentioned, as well as practically all other manufacturing establishments in the neighborhood, closed down, the writer took readings in the house and found the maximum to run from 0.75 to 1.0. An assistant walked around the same floor 25 ft. from the instrument and the reading rose to 2.0. When he walked in the upstairs rooms it was 1.5, and when he walked in the same room it was 4.0.

To give basis for a comparison of the vibration in the plaintiff's house with that in other houses in the city readings were taken in four other typical residences. In two houses on street car lines the maximum reading when street cars were passing ranged from 1.0 to 1.5. Steam railway trains passing from 255 to 400 ft. from houses produced a maximum reading of 1.50 to 1.75. Heavy motor traffic on a street 250 ft. from another house gave readings as high as 1.0 to 1.5. No street car traffic existed nearer the latter than 800 ft.

Conclusions.—The observations thus made led to the following conclusions, which may be of interest and suggestive value in similar situations:

1. The vibration existing in the plaintiff's house with the adjacent plant running was, except for occasional large disturbances, no greater than exists in typical residences on street car lines, and considerably less than occurs in those residences when street cars "Y" at a nearby corner or a railway train passes anywhere within a distance of 400 ft.

2. The maximum observed vibration in the plaintiff's house produced by operations in the plant did not at any time exceed that arising when a light engine passed on the railway main line and was considerably less than arose from nearby switching.

3. The vibration produced by a man walking in the front hall of the plaintiff's house, or moving rapidly up or down stairs, or walking in the rooms upstairs was at least as great as rose from any cause in the plant.

4. The occasions when the operations in the plant raised the vibration to equal that produced by a passing engine arose infrequently. Such cases were observed only twice in 1¼ hours and for a short period of about three minutes at a time.

5. The objection of the plaintiff to the disturbances created on the defendant's premises probably arose more from the steady persistence of moderate vibrations during working hours than from any large magnitude thereof.

Based on observations made in this and other vibration cases, the writer is of the opinion that there is a disposition to magnify the effects of small but incessant vibrations and to view lightly the much larger vibration effects of casual disturbances. Like the constant dropping of water on the proverbial stone, the continuous repetition of small tremors appears ultimately to wear down the nervous resistance of those coming within their range. Occasional large vibrations do not appear to produce the same annoyance.

Rod Make-Up Diagram

By HARRY J. FINEBAUM.

Every reinforced concrete problem requires the choosing of a combination of steel rods to make up the necessary area of steel, whether the latter is in tension or compression.

The choosing of this combination is often a source of much hesitation to the engineer when deciding which will best satisfy the conditions. The accompanying diagram will facilitate the designer's decision and will show at a glance all the possible combinations of rods which will give the required area.

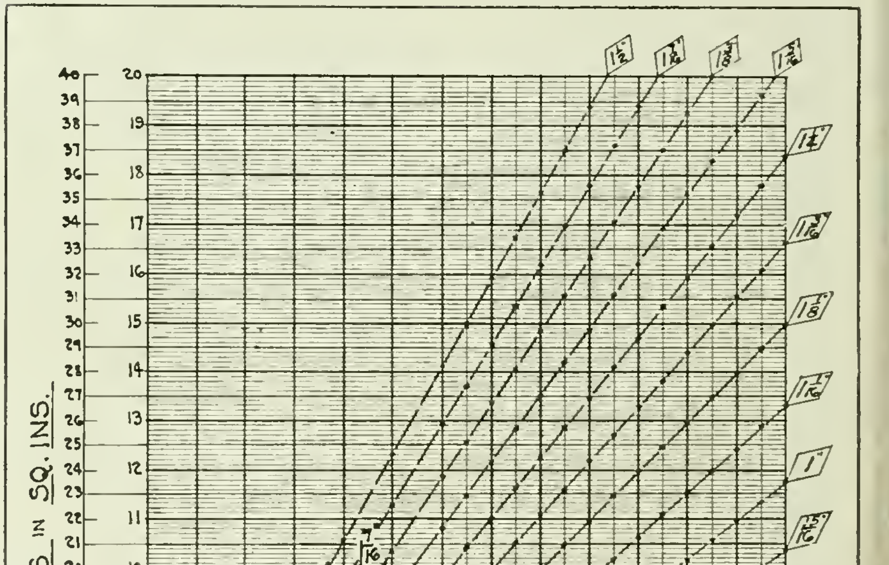


Diagram Showing All Possible Combinations of Rods for Required Area of Reinforcing Steel.

The following considerations are in line with present practice:

1. All rods are plain and round.
2. All rods in any combination are of the same size.
3. Maximum size of rods 1½ in., minimum ⅜ in.

The diagram gives combination of rods up to 40 sq. in. and it is believed that this range will include the largest size concrete girders that may come within any engineer's experience under our present specifications. Attention is called to the double scale of ordinates and abscissae by means of which it is possible to double the scope of the diagram to include 30 rods and 40 sq. in., whereas the single scales would only give 15 rods and 20 sq. in. The outside scales at the left and at the bottom are used only when the number of rods exceeds 15. Suppose an area of steel of 15 sq. in. is required—then, using the larger scale of ordinates, trace the horizontal line corresponding to 15 sq. in. until it intersects the diagonal lines at any of the dots on the vertical lines. It will then be readily seen that the only combination which exactly satisfies is 15 — 1⅛ in. rods. Other combinations are 10 — 1⅜ in. = 14.85 sq. in. and 11 — 1 5/16 in. = 14.85 sq. in.

Using the larger scale of ordinates: then on the horizontal line corresponding to 15 sq. in. will be found dots at the intersection of the diagonal and the vertical lines giving the following combinations:

17—1 1/16 in. = 15.1 sq. in.
19—1 in. = 14.9 sq. in.
25—⅞ in. = 15.0 sq. in.
29—13/16 in. = 15.1 sq. in.

If the size of the rods is predetermined, then the number required to give a required area is quickly ascertained, while when the number of rods is fixed by other conditions the size of the rods is quickly obtained from the diagram.

The diagram will also be found useful in checking designs, for the number and size of the rods being given, their area is immediately read off.

Revision of National Electrical Code

The U. S. Bureau of Standards is co-operating in the revision of the National Electrical Code, which is published by the National Board of Fire Underwriters. The preparation of the 1923 edition is being carried out with the assistance of a number of technical subcommittees dealing with particular subjects. A member of the staff of the Bureau of Standards is chairman of the technical subcommittee on service entrances. This subcommittee met at the Bureau of Standards on Sept. 15, and agreed upon recommendations for revision of the rules dealing with the equipment (switch, fuses, meter) located at the point where electric service wires enter a building. These recommendations will have to be approved by the electrical committee of the National Fire Protection Association before they become effective.

Prize Contest for Papers on Use of Vitrified Clay Pipe in Plumbing Systems.—The College of Industries at Carnegie Institute of Technology, Pittsburgh, announces a prize contest for the best papers written on the subject of "The Use of Vitrified Clay Pipe in Plumbing Systems."

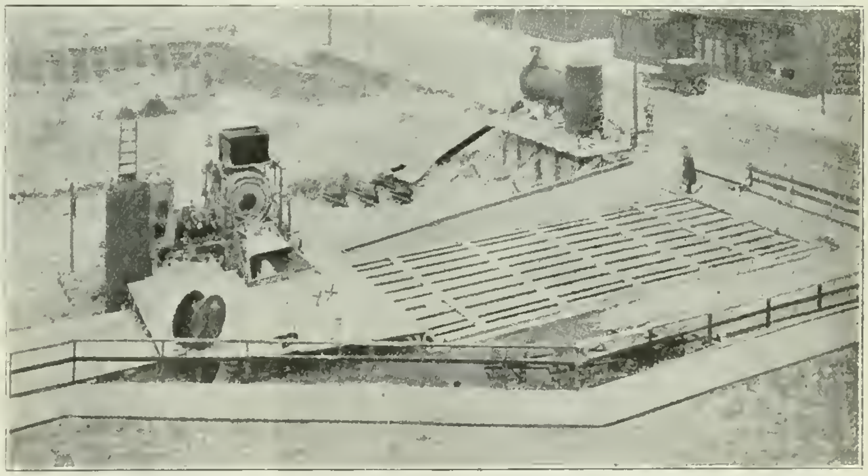
Concreting Operations in Cold Weather

Methods of Carrying On Structural Concrete Work in Winter Months Described in Recent Booklet of Portland Cement Association

In order to place concrete successfully in cold weather, it is necessary to be prepared to use somewhat different methods than in summer months. The fundamentals of these methods are easily comprehended by an understanding of the action of concrete in hardening.

Hardening of concrete is not a process of drying out as some people suppose, but is a chemical reaction between the cement and the water used in the mixing. Two things are necessary for proper hardening —namely, warmth and moisture.

Low temperatures will retard the hardening of concrete, extreme cold will prevent it altogether. Since water is necessary for the chemical action of hardening, evaporation of the water used in mixing the concrete must be prevented. This is often done by keeping the surface covered with wet sand, sawdust or burlap. As the temperature is lowered and the moisture content is reduced, the gain in strength and the entire hardening process become much slower and practically cease when the temperature of the water used in mixing falls to the freezing point.



Special Pipe Grillage for Heating Aggregates Installed by Thompson-Starrett Co.

The picture shows the complete installation of pipes, boiler and mixer. Steam boiler has been removed from the mixer frame and used to heat water in tank on top of mixer; electric motor substituted for former steam motive power. Loaded trucks of sand and gravel were dumped directly on to this platform. As soon as covered to a depth of 3 feet, steam is turned on continuously day and night.

If concrete that has frozen once is thawed out and protected from freezing again, it will harden properly providing no appreciable loss of water used in the mixing has occurred. In this case, the hardening process is merely suspended during the frozen period. However, if alternate freezing and thawing occur several times, the concrete will be seriously injured and may have to be torn out. The exact period that may be allowed to elapse between placing concrete and subjecting it to freezing temperature cannot be definitely stated because of the influence of unknown variations in temperatures and other conditions. However, experience shows that this period should never be less than 48 hours and if the temperature averages below freezing 3 to 5 days should be allowed.

METHODS FOR WINTER WORK.

Heating Materials.—Since warmth and moisture are required for the proper hardening of concrete, cold weather work should be planned with those necessities in view. The methods to be used on any particular job depend, of course, upon the local conditions. Both the mixing water and the aggregates should be heated. The cement forms but a small portion of the concrete and need not be heated, but it is well to keep it in a warm place for a few hours before it is used.

The nearer the water is to the boiling point the better will be the results because it will take longer to dissipate the heat and cool the mixture. There are several types of water heaters that can be used, but the most common method of heating is to pass steam into the water tank. The concrete should be mixed with the least amount of water practicable to produce a workable, plastic mixture. An excess of water should be carefully avoided.

Many methods are used for heating aggregates. A simple method is to use a length of iron pipe, an old boiler, or any metal cylinder over which the sand, broken stone, or pebbles can be piled, and in which a fire can be built. Care must be taken to heat the fine and coarse aggregates separately in order to avoid pre-mixing them in wrong proportions. As this method entails rehandling the aggregate, and as some aggregates are affected by excessive heat, the use of steam pipes is generally preferred.

Steam heating is a more expensive method and requires a steam boiler, but on large jobs this method is usually advantageous because the steam may also be used for other purposes. A practical method is to use a perforated steam pipe with a pointed end which can be worked into the piles of aggregates. To reduce loss of heat the piles of aggregates should be covered with tarpaulin.

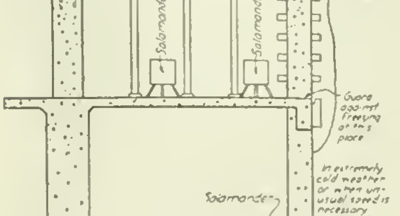
If the materials are heated as above outlined, and the concrete is deposited immediately after mixing, its temperature when placed in the forms will be around 80° F. and if care is taken to prevent too rapid loss of this contained heat, the concrete will harden properly. The early stages of hardening may be even more rapid than under ordinary conditions.

Heating the Forms.—The forms must be free from snow, ice and frost, and should also, if possible, be reasonably warm, especially in the case of metal forms, which will absorb heat from the concrete rapidly. Live steam is an effective agent for cleaning ice, etc., from the forms, and warming them. It should be used just before the concrete is placed.

Protection and Supplying Heat While Hardening.—A rapid loss of contained heat must be prevented. Protect the concrete while hardening so as to maintain the warm, moist condition essential for the rapid development of strength. There are many methods of doing this: the most common is an enclosure of canvas or tarpaulins. In mild weather this alone may be sufficient, but when the temperature drops below the freezing point, some means should be provided for heating the enclosure. Steam escaping from perforated steam pipes around the concrete will give the best results, because the steam saturates the air and prevents evaporation of moisture from the concrete.

A Close-up of the Arrangement of the Pipe.

Grillage drips for condensation are shown on the left hand side. This installation produced an aggregate with a temperature of approximately 70° at all times.


Canvas Covering
Steel 8"x 8" heat hole
2"x6" Clamps
End View
Salamander
Salamander
Guard against freezing at this place
Salamander
In extremely cold weather or when unusual speed is necessary curtain this story and place one salamander by each exterior column

Cross-Section of Building Under Construction During Winter Months, Showing Placing of Salamanders and Canvas Covering.

Coke salamanders or stoves are often used when steam is not available to supply warmth to the enclosure, but large pans of water should always be placed on or near them in order to provide as much moisture in the air as possible. Care should be taken not to have these stoves or salamanders so close to the concrete as to dry it out in spots. An even temperature of at least 60° F. should be maintained at all times in all parts of the enclosure. To maintain this temperature within a properly housed enclosure during cold weather, it may be estimated that with good coke properly handled one salamander will be required for every 300 to 500 sq. ft. of floor area.

In some cases the entire structure has been enclosed in a temporary wooden building but in general a canvas covering will be cheaper and just as effective. For retaining walls and similar structures a light roofing paper envelope placed outside the forms with steam pipes at the bottom has proved satisfactory.

Protective Coverings.—When it is warm during the day with a temperature drop close to the freezing point at night, floors, pavements and foundations are often protected by covering with straw, hay or other material with satisfactory results, but such covering should not be relied upon during protracted low temperatures.

Even though the outdoor temperature may not drop to freezing, suitable protection is necessary to prevent the concrete from losing the heat introduced by heating the materials, and insure proper hardening. At low temperatures the heat developed by the chemical reaction of the cement and water is too small to be safely relied upon except in large masses underground. Even in those cases the materials should be heated and the surface protected.

Thin structural members and floors have such a large surface area in proportion to their size and the heat within the concrete is dissipated rapidly, and therfore protection must be provided.

Application of Load.—Too early removal of forms is always to be guarded against even during construction in favorable weather, and great caution should be observed in placing loads upon cold weather concrete. Especially is this true of walls, roofs and floors above ground, which carry loads other than their own weight.

Before removing forms the concrete should be examined to see that it has properly hardened and not frozen. A reliable test is to apply heat to the surface by means of a blow torch or a jet of hot water or steam against it.

Frozen concrete will be disclosed by softening as it thaws out, but if properly hardened, the concrete will be unaffected by the application of heat.

Summary of Important Points.—Points that should be observed in cold weather concreting are summarized as follows from the instructions to superintendents of the Turner Construction Co.:

Aggregates are heated to best advantage by 1½-in. steam pipes laid as a grill under the piles or by a 6-ft. length of perforated pipe insert, inserted into the pile.

Water is heated by running a 1½-in. steam pipe into the water barrel.

A 50-hp. boiler, carrying 50 to 60 lbs. of steam is required for a large job, but an 18 to 25-hp. boiler is sufficient for jobs of not more than 5000 sq. ft. of floor area.

One salamander is usually sufficient for 300 sq. ft. of floor area and a heat hole should be provided for each salamander.

Columns should be concreted the same as the floor and column tamping continued for an hour or more after the floor is concreted.

Bases of exterior columns are most difficult to protect and in extremely cold weather a salamander should be placed on two sides of exterior columns.

For unusual speed or cold weather or when monolithic walls are carried up, the lower floor should be curtained and salamanders placed at exterior columns.

Apply fuel to salamanders frequently and in small quantities to minimize smoke and provide uniform temperature.

Water barrels should be provided to extinguish fires and care taken to secure canvas against blowing against salamanders.

A detailed temperature record should be kept showing date, hour, outside temperature, temperature at bottoms of columns, underside of slab, under the canvas over the slab, temperature of concrete as deposited and, especially, temperature at bases of exterior columns on windward side of building.

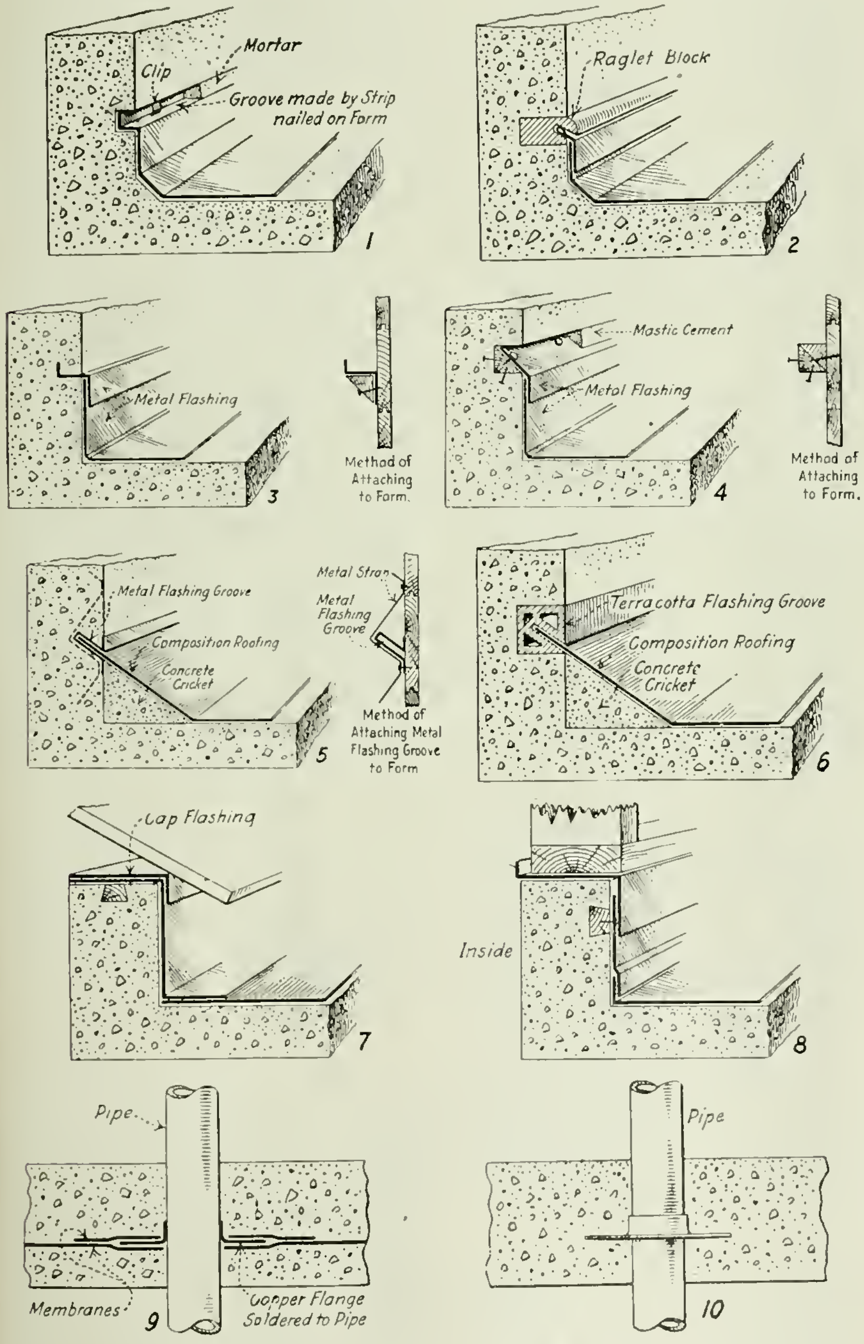
Standard Zoning Law

A standard law for the assistance of those responsible for the framing of state zoning enabling acts has just been issued by the Department of Commerce. Zoning ordinances for the regulation of use, height, and area of buildings are being adopted by cities in almost every state in the Union, and in some states where there is no specific authority for zoning, these ordinances may be set aside by the courts. An enabling act is advisable in all cases.

The Department of Commerce model for an enabling act under which municipalities can adopt zoning regulations is a 20-page, mimeographed document with foot-notes covering questions which might arise in the wording of various sections and provisions.

Concrete Roof Flashing Details

Most concrete roofs are flat or with just sufficient slope to give the proper drainage, and in many cases the roof is surrounded by a low parapet wall for the sake of architectural appearance and for convenience in carrying off the drainage water. With concrete roofs it is the almost universal practice to provide a bituminous roofing. An important detail is the connection between the flashings of the roofing and the parapet wall. Many methods have been devised to accomplish this. Some of the more common and successful of these are shown in the Contractors' Atlas, from which the matter following is taken.



Figs. 1-10.—Ten Methods of Making Connections Between Roof Flashings and Parapet Wall.

In the type shown in Fig. 1 a groove is left in the wall by nailing a strip of wood to the forms. The flashing is bent up into the groove and held in place by metal clips. The groove is then filled with either a cement mortar or mastic cement.

Figure 2 shows a construction in which the flashing, usually of mastic or felt, is let into the wall by means of a raglet block, cast in place in the concrete. The groove in the block is then filled with mastic cement.

In the type, Fig. 3, the cap flashing is cast into the concrete wall. This is done by bending the flashing into the proper shape and nailing it against the inside of the form. To prevent its sagging under the weight of the concrete it is supported at intervals by small triangular shaped blocks which are nailed to the forms. The roofing slides up under the cap flashing.

In the construction shown in Fig. 4 a groove is left in the wall by nailing to the forms two triangular shaped strips. The lower strip has nails protruding which allow it to bond to the concrete. On removing the forms the upper strip is removed and the lower one is left in place. This provides a nailing strip for the flashing. The groove is later filled with mastic cement.

In the method shown in Fig. 5 a raglet is made in the concrete by means of a metal trough held in place on the concrete forms by means of metal straps. A concrete cricket or slope is made, usually of cinder concrete, of the same slope as the raglet groove. The composition roofing is then brought up into the groove directly.

The method shown in Fig. 6 is quite similar to that shown in Fig. 5 except that a terra cotta raglet block is used instead of the metal type.

In the case of a low skylight parapet wall shown in Fig. 7 the flashing is laid over the top and extends down the side. It is held in place by a block cast in the top of the wall.

In the case shown in Fig. 8 the skylight flashing is held on the side of the wall and the cap flashing extends down over the top of the flashing.

In Figure 9 is shown a case in which a pipe passing through a concrete slab is given a watertight joint by screwing into it a collar with a wide flange.

Figure 10 shows a method of flashing a pipe that passes through a floor waterproofed by the membrane system. A copper flange is soldered to the pipe and is covered top and bottom by the membrane. Where the pipe extends through a roof, the membrane is omitted.

Variations Found in Leveling Devices

There is a marked difference in the sensitiveness and quality of spirit levels offered for sale for the use of masons, carpenters, machinists, and the like, according to a Technical News Bulletin of the U. S. Bureau of Standards. This has been brought out by field studies of the Bureau of Standards on the installation of heavy capacity scales. In examining the alignment of scale parts installed in pits, certain discrepancies were noted. Attention was finally directed to the leveling devices used, and a simple, practical scheme was worked out by the Bureau for testing them which may be used to advantage even in a small shop. The method was then applied to the test of various levels which were found available in the scale shop.

In three levels of the same make and provided for the same purpose, it was found that one was several times as sensitive as the other. One of the vials likewise showed a marked lack of uniformity in sensitiveness, since a given change of level would cause a greater movement of the bubble from the center of the tube in one direction than the other. The levels tested included an arrangement of two level vials at right angles to each other, which was being used for specially accurate work. It was found in this particular case that there was a marked lack of sensitiveness in this special device, in fact it was much less sensitive than any of the other less pretentious vials which were tested.

It would appear, therefore, that anyone wishing to carry out highly accurate work should be positive that the levels used are carefully made and sufficiently sensitive; otherwise, serious errors may result.

Concreting Plant for Building Construction

Efficient Layout That Saved $90 a Day in Labor Costs Alone Described in The Constructor

By RICHARD P. WALLIS.
The Lundoff Beckwell Co., Contractors.

The success or failure of a construction operation depends in no small manner upon the layout and equipment of its concreting plant. By the concreting plant is meant the mechanical equipment for receiving, storing, mixing and depositing the materials that constitute the concrete frame of the building.

The objects sought in providing these devices as a substitute for human labor in the carrying on of these operations are to increase the speed and to reduce the unit cost of preparing and placing this concrete. These requirements constitute the criterion by which the performance of the plant is judged.

As practically each building operation is unique in its character, so may we expect to find separate and distinct problems to solve in meeting individual job requirements. There are, however, two fundamental principles that are common to all efficient plant layouts. In the first place, the continuity of supply must be guaranteed against interruption so as not to jeopardize the successful placing of the concrete; furthermore, the force of gravity should be employed wherever possible to convey material from one location to another.

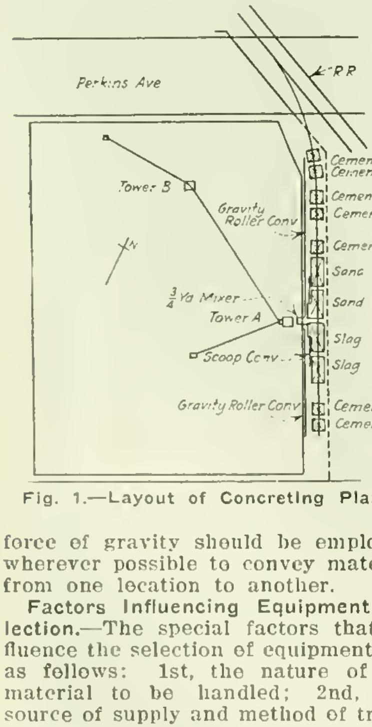


Fig. 1.—Layout of Concreting Plant.

Factors Influencing Equipment Selection.—The special factors that influence the selection of equipment are as follows: 1st, the nature of the material to be handled; 2nd, the source of supply and method of transportation; 3rd, local physical conditions; and, 4th, the initial cost and probable salvage value of such equipment.

The equipment decided upon must be well adapted to the purpose for which it is intended. Cement in bulk requires one type of conveyance, while in sacks it must be handled by other means.

The source of supply and method of transportation exercises a considerable influence in the choice of this equipment. If the aggregates are obtained from local sand and gravel banks, special washing and screening apparatus will be required as well as excavating equipment. If brought to the site by water, rail or truck, unloading devices must be provided that will function in a satisfactory manner in each case.

The arrangement of the buildings, their height, the quantity and distribution of the concrete to be placed, and the amount of available storage space must be considered before deciding on any particular layout. Existing rail or dock facilities must be investigated as well as the topographical features of the site. The plant layout must be shaped to profit by any special physical condition that may exist at the start of operation.

The initial cost and probable salvage value of equipment should be considered before determining the final layout. Equipment may be selected that will expedite the work of manufacturing concrete yet, owing to its prohibitive cost, increase the unit costs to such a point as to wholly nullify its usefulness in that respect. The salvage value of equipment of this character is variable and depends upon the original cost of the equipment and on the care received by it during the operation.

Over-equipping a plant is as unfortunate in its consequences as is failure to provide sufficient equipment to fully utilize the existing advantage. Additional plant should be installed only when it is clear that such addition will satisfy the criterion of speed and cost.

The final layout should be determined upon only after a careful consideration of all these factors. The plant should be well balanced throughout—that is, all parts should be selected so as to function in an efficient manner without loss of time or materials. A basic principle of engineering construction is to make no one part better or stronger than the rest. This same principle applies to the selection and arrangement of concrete plant equipment.

A Model Plant Layout.—The plant layout in the new building now under construction by the Lundorff-Bicknell Co. for the Ward Baking Co., at 46th St. and Perkins Ave., Cleveland, contains numerous interesting features and admirably illustrates the application of many of the above principles to a typical plant layout.

The building itself covers an area of 260 ft. by 315 ft. and varies in height from 20 to 60 ft. The floors of this building are of reinforced concrete, designed as flat slabs averaging 7 in. in thickness and carried on heavy concrete columns. Altogether, including floor, columns, foundation, etc., there are approximately 10,000 cu. yds. of concrete in the finished structure.

The building is located in a built up district of the city and occupies approximately 70 per cent of the entire lot. This limitation of available storage space necessitated a careful preliminary study of the possibilities offered by the use of mechanical equipment in the efficient handling and placing of this concrete.

Fortunately there existed at the start of operation an 18-ft. wood trestle along the entire east side of the property carrying a single track spur from the main line of the C. & P. Division of the Pennsylvania R. R. The entire plant was planned and erected with especial reference to the use of this track in the delivery of materials.

Sand, slag, stone and sacked cement are brought to the job in carload lots. The bottom-dump cars are spotted on the trestle over the respective bins and sheds and their contents unloaded by gravity. The aggregates are dumped through the hoppers to their respective bins, while the cement is dropped directly down through chutes to the various sheds below.

Power for shifting these cars locally by means of a cable and nigger head located at one end of the trestle is obtained from the same 75 H. P. McMyler boiler that operates mixer, hoist and pumps.

Storage.—As will be noted from Fig. 1 there are two sand bins, each with a capacity of 150 cu. yd. and two slag bins of similar capacity. It was found necessary to build twin bins for both sand and slag owing to lack of sufficient height beneath the trestle for a single bin with a storage capacity adequate for a day's continuous pouring. This arrangement was made possible by the use of two power-driven Jeffery belt conveyors that elevate the material from the outer bin in each case to that adjacent to the charging hopper. These conveyors are operated by 5-H. P. electric motors and have a lifting capacity of approximately one cubic yard per minute.

There are seven cement sheds with an average capacity of 950 sacks (one carload) each. Sheds No. 1 to No. 6 inclusive are for daily use, while shed No. 7 is held as a reserve in case the unexpected happens and the supply of cement is interrupted. Carload lots of cement are not used until after the report of the seven-day test has been received. Until then a sign bearing on one side the words "Do not use" is placed on the door of the shed containing that particular carload. Upon approval this is reversed to read "O. K." and the cement is ready for use.

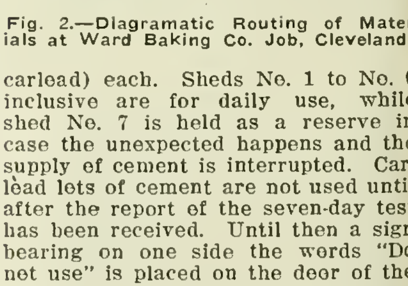


Fig. 2.—Diagramatic Routing of Materials at Ward Baking Co. Job, Cleveland

Mixing.—The material from the inner bins is admitted directly to the charging hopper of the mixer, which is located in a pit directly between and below these bins, through steel cut-off gates operated by hand. This charging hopper is divided into two portions by a vertical partition so that the proper amount of sand and slag for each batch is easily determined by filling each portion to the proper level. The cement is brought to the charging hopper from the various sheds by Matthews gravity roller conveyors. Wood pallets with a capacity of 3 sacks each (enough for one batch) are provided for this purpose. The empty sacks are shaken, counted and tied in bundles of 50 each, and are stored near the cement sheds for ultimate return to the mill.

Water is supplied from city mains and is measured by means of a tilting barrel conveniently located on the mixing platform. The flow of water is controlled by means of a quick acting valve located at the barrel. The charging hopper when filled with the proper charge of material for the batch, discharges into a ¾-yd. Smith tilting mixer, operated by an Orr & Sembrower 10-H. P. vertical engine geared direct to the mixer and supplied with steam from the main boiler, where it is properly mixed.

Distribution of Concrete.—The batch is discharged into the hoist bucket and elevated in the main tower "A" a distance of approximately 150 ft. to a receiving hopper. A 10-in. by 10-in. single-drum McMyler mine hoist is used for hoisting the concrete. This main tower has a second receiving hopper located part way to the top which, as the work progresses, may be raised by means of a winch located at the tower base. This latter hopper discharges into a floor hopper through a 100-ft. section of Lakewood trussed steel chute, jointed in the center and supported from the tower by steel cables, which is used to deposit concrete to the area immediately adjacent to the mixer. The concrete from the top hopper is spouted to a second receiving hopper in tower "B," some 155 ft. distant, by means of a line chute with a fall of 4 in. to the foot, supported by block and tackle from a steel cable strung between the two towers. It is then distributed to the various locations by means of an adjustable section of chute 100 ft. long, jointed in the center and supported by cables from the top of tower "B." Lakewood chutes are used throughout in this equipment; these are semi-circular in section and have a radius of 7½ in. Swivel joints and splash hoods are provided where necessary to insure the flexibility of the operation and to prevent loss of materials.

The towers are of wood, 9 ft. square, and are built of 6-in. by 6-in. posts, 2-in. by 10-in. ledgers and 2-in. by 8-in. cross braces, all securely spiked together in 7-ft. bents and well guyed.

Plant Capacity.—As the specifications state that all concrete must be placed by hand, floor hoppers supported on platforms are provided at the end of each chute for loading the concrete into buggies. The layout calls for a maximum distance of 150 ft. that concrete must be buggied.

This plant is designed with the idea of mixing and placing a maximum of 350 cu. yd. of concrete per 8-hour day. To supply the necessary amount of materials for this quantity of concrete there are required about 195 cu. yd. of sand and 300 cu. yd. of slag. This is the approximate capacity of the combined bins, so it is necessary to restock the bins at least once a day during the interval of continuous pouring. The cement sheds have a total capacity sufficient for from four to five days' continuous run at maximum capacity. The railroad company makes two switches a day, which is sufficient to keep the bins well stocked at all times.

Provision is made for preheating the sand and slag during freezing weather by means of steam coils inserted in the bins and supplied by the same boiler that furnishes steam to the hoisting engine and mixer.

Costs.—It is estimated that through the use of this plant equipment the cost of stocking sand and slag has been reduced to approximately 3 ct. and 4 ct. per cubic yard, respectively, and that cement is handled for approximately 7 ct. per barrel. Handling, mixing and placing costs for this concrete is in the neighborhood of 90 ct. per cubic yard. This cost is somewhat higher than it would be were it possible to spout the concrete directly into the forms.

Five laborers are used to operate this plant back of the mixer, one tending the water, one each at the sand and slag shut off gates, and two handling the cement. Two engineers are required, one at the mixer and one on the hoist. There is also one laborer in the pit to keep it clean, while another is stationed in each tower during pouring to regulate the flow of concrete through the hoppers and chutes.

The use of this equipment does away with an additional force of 15 laborers behind the mixers, who would otherwise be engaged in handling the concrete materials. This means a saving of $90 a day for an equivalent of 40 days' continuous pouring, or a total of $3,600. As the total cost of the equipment exclusive of possible salvage is in the neighborhood of $10,000 this saving alone represents 36 per cent of the equipment cost. This saving is equivalent to 36 ct. a cubic yard of concrete. The cost of this equipment per cubic yard of concrete is approximately $1.00.

Pile Butts Sawed Into Form Lumber

In the construction of Pier No. 3 at Philadelphia, the contractors, Frederick Snare Corporation, utilized the pile butts for form lumber. The work involved the driving of 7,195 timber piles. The butts were brought to a saw rig on an adjacent pier. By means of the saw, which is of the traveling carriage type, the butts, varying in length from 5 to 12 ft., are sawed into lumber suitable for forms. According to Successful Methods, one sawyer and two helpers, whose wages aggregated $14 per day, sawed about 6,000 ft. in 10 hours. The saw was steam driven, steam being furnished from the contractors' central plant.

Measurement of the Color-Temperature of Artificial Light Sources.—Scientific Paper No. 443 of the U. S. Bureau of Standards, dealing with the measurement of the color-temperature of the more efficient artificial light sources, has been published by the Government Printing Office. In it is described and discussed a new method for measuring color temperatures between 3,000 and 4,000° absolute centrigrade. Data are presented on the color-temperature of the gas-filled tungsten lamp and the carbon arc. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 ct. each.

Accident Prevention in Construction Industry

Abstract of Address Delivered Aug. 29 at the 11th Annual Safety Congress of National Safety Council

By R. C. MARSHALL, JR.
General Manager, Associated General Contractors of America.

Accident prevention until some 20 years ago, received its principal impetus through laws instigated by employes or students of sociology and often bitterly opposed by management, but since then the situation has radically changed. We find that management itself is stepping far beyond the statutes to provide safe conditions of employment and to conserve the health and lives of workmen. This safety movement which has been coordinated and extended by the National Safety Council, through the support of some hundreds of industries embracing over 4,000 companies, is now reducing the frequency of accidents in many lines of production, and is lowering production costs. Its benefits to both employes and management have been proved by actual performance.

Three Features of Accident Prevention—The success and momentum which the work has gained is unquestionably attributable to three good and practical features of accident prevention. These features which have been repeatedly emphasized by writers and speakers interested in safety work are:

1. Mitigation of suffering and hardship to disabled workmen and their families.
2. Reduction of production costs.
3. The improvement of industrial relations.

The first, a humanitarian benefit, requires but a moment's reflection to stir an appreciation of its need and justify the effort to secure it in construction. Constructors are desirous of reducing the physical suffering and poverty caused by accidents in an industry, and any slowness in getting actively behind the move should not be attributed to indifference. If safety work is lagging unduly in the construction field it is due in great part to the fact that contracting is still, to a great extent, a one-man business without specialized departments and that the life of the individual heads of small and medium-sized companies is a strenuous existence. Their energies have of necessity to be concentrated on the most tangible and pressing problems. The desire to alleviate the suffering is with them as with other humans, but progress will doubtless be slow until the conception of safety work as a concrete and tangible factor is better understood. Having acquired an understanding of the methods of tabulation, study, classification and application of safety measures, constructors both large and small can be counted on to more actively attack the problem.

The humanitarian aspect of accident prevention alone warrants the efforts already devoted to safety work, but it is also supported and justified from the financial standpoint by the saving of safety, or, in other words, the lowering of production costs. Actual experience has demonstrated that accident prevention cannot properly be viewed as an added expense, because, like the cost accounting system, it not only justifies the expenditure, but also more than pays its way.

How Safety Work Reduces Construction Costs.—At the present time and for some years to come, the lowering of construction costs is a problem to which construction companies must bend increasing energy. The inverse ratio of construction volume to construction cost is a simple economic axiom, and contractors realize that to maintain the volume they must resist the rising tendency of costs. The poor economic reasoning of simply passing the expense along has been shown up by the manner in which such procedure quickly checks demand, and the wiser course of keeping costs at a minimum now seems to be universally accepted. The problem, therefore, has become one of estimating at a profit without driving out the marginal buyer of new construction, and it means eliminating every unnecessary expense. In doing this the saving of safety work can assist in a number of ways, which may be outlined briefly as follows:

The reduction of accidents by an individual company enables it to obtain from the insurance companies a special rating on experience. This rating means that the company obtaining it pays a premium on its liability insurance that is lower than the standard rate. A representative of one insurance company cited a case at the last annual meeting where one constructor obtained a reductin of 30 per cent. The accomplishments of the Fred Ley Co., which reduced its accident frequency some 85 per cent in three years, is an instance well known to those who have followed accident prevention in construction. Another instance cited at the convention last year was that of a Massachusetts manufacturer who was saving over $100,000 a year on insurance premiums. In construction, where the average premium may run as high as 8 per cent of the total labor costs and as much as 20 per cent in specific trades, these economies are assuredly worth an effort.

There is also the item of direct labor time lost through accidents. Mr Davison of Dwight P. Robertson & Co., last year showed where, over a period of some three months, this company had spent about $9,000 in lost time. Where the accident frequency is high, this item assumes significant prportions.

Effect of Frequency of Accidents on Wages.—Wages themselves are based to a degree upon the hazard factor and in general are increased with frequency of accidents on the work. In reality the hazard rate means very little to the workman in the long run, as in case of disablement it is not sufficient to compensate for the disability. This rate stands as an undue expense of the work. A better plan would be to reduce the hazard and eliminate the necessity for excessive hazard wages.

Another wasteful effect of accidents is the indirect loss arising from poor efficiency and morale of the working force when disrupted by serious accidents. Moreover, for every man disabled another must be trained and the cost of his training stands as a charge against construction. Each such accident represents a more or less distinct increase in labor cost. A reduction of all of these items is not only possible but has been accomplished by individual companies through the application of safety methods.

Three Benefits from Accident Prevention.—Reduction of cost and preservation of human welfare are the two most tangible benefits from this work; but the third, a less perceptible one, is of scarcely less importance and probably it is the most urgent; this is the improvement of industrial relations.

Industrial relations of which so many volumes have been written in recent years, and which were once considered a subject that had principally to do with educators and social students, is today a real factor affecting every manufacturer and every cotractor. Though not a new problem, it has in recent years raised many new difficulties in the conduct of construction operations. A glance over industrial history since mediaeval times is sufficient to demonstrate that as industry expands and as the nation turns more from an agricultural to an industrial country, the complexities of industrial relations increase. Sooner or later these complexities must be ironed out by constructive efforts on the part of both labor and management, and each step that management can take to make the interests of labor and itself coincident constitutes a gain for both.

Safety Work Engenders Co-Operative Spirit.—When employes know that management is exerting an earnest effort to protect them from occupational accident, a more co-operative spirit is certainly engendered. It eliminates in a measure the hardness and soullessness with which modern industry is charged, and makes up in some degree for the personal contact that has been lost. It is questionable whether the blame for antagonism rests solely upon the employes, when we recall that during the last generation those humanitarian measures of safety provision now commonly accepted as reasonable and proper were bitterly opposed by a majority of employers.

Safety work backed by management itself obviates the need of safety statutes which for years afforded practically the only means of instituting safety provisions. It not only accomplishes far more than can ever be required by law, but removes one important obstacle to mutual understanding. Safety work in construction, where the period of employment with individual companies is usually short, is believed to have produced a marked improvement in industrial relation between the employes and those companies who have carried on such work.

In the matter of holding an organization together during a period when labor is scarce, the advantages of safety work become apparent. Those companies that have carried their safety promotion to an effective point undoubtedly find it an asset in holding their men. It is conceivable that the time may come, in construction as in certain manufacturing industries, when workmen will be able to choose between the companies who make their work as safe as possible and those who disregard safety.

Accidents Decrease Workers.—There is another consideration which all of us might consider who deplore the increasing cost of government. The drain on state and federal income incurred through caring for persons disabled is something worth considering. Every disabled workman in the building industry, where the supply of labor is insufficient, adds to the labor problem; and every disabled worker in any industry takes one unit from the ranks of producers and, when his maintenance falls upon the community, adds an increment to government expense.

If a census of construction companies were taken to ascertain the attitude concerning safety work, we should doubtless find that it is almost universally approved. Yet a great many companies have not undertaken the work. The difficulty, as already mentioned, is that they are not familiar with the means of carrying on this activity. They need further explanation of the subject and some standard concise procedure for making investigations and interpreting the result. The National Safety Council provides the means through which contractors can learn and apply proper methods of accident prevention, but the standardization of safety work is yet to be carried out for the construction industry. In this work the assistance of every construction company is merited.

What the Council Is Doing.—The Council is already rendering service which includes the following features:

(a) A clearing house for the exchange of safety methods, which affords distribution of approved practices to the various industries and to individuals in the same industry. The Construction Section carries on this work especially for contractors, by means of literature and posters explaining methods and devices applying to different classes of accidents.

(b) Special investigations and original research which are finding new methods of prevention and devising systematic means of recording accidents, so that they may be controlled as a concrete factor in production. Some 50 or 60 pamphlets, the result of special investigation, which treat of specific measures of safety work, a number of which are applicable in part to construction, have been distributed.

(c) A comprehensive information service which furnishes posters, job bulletins, descriptions of devices and emergency measures together with news reports of the progress of safety work in many industries. Through these, some of which apply in part to construction and some of which are especially devoted to construction, contractors are able to gain information for conducting effective safety work.

The Construction Section of the National Safety Council.—The Construction Section, which has a membership of something over 200 companies, has done valuable work and should be expanded in both service and membership; but until the membership is increased the service cannot be extended to cover adequately the four or five major divisions of the industry.

Many special hazards are encountered in construction which should be called to the attention of superintendents and workmen by means of proper literature, job signs, and illustrated posters. Moreover, each division of construction has its own peculiar hazards which need special investigation and presentation to the working force. These needs are understood by the officers of the Construction Section who have given a great amount of personal time to the work, but they cannot carry out the necessary service without additional support from those who are to derive the benefit. Every member of the Construction Section should act as a personal solicitor for membership, thus helping to provide the means for carrying on the work.

Cost Accounting for Construction Work

System Employed By the Aberthaw Construction Co. Explained in Paper Presented at Construction Industries Conference at Hamilton, Ont.

By W. N. CONNOR,
Chief Cost Accountant, Aberthaw Construction Co., Boston, Mass.

There have been many books, pamphlets and papers published on cost accounting, but very few dealing with its application to construction work. One reason for this is that so few contractors keep a thoroughly accurate check on their costs or maintain a standard cost system. A majority rely on their bookkeeping department to furnish them cost data. This, to my mind, is doubtful practice as a bookkeeper deals in absolutely accurate figures down to a penny, while the cost accountant's viewpoint is somewhat more liberal.

I do not mean by this that the cost accountant's figures need not check with the bookkeeper's ledger, for they must; but the training of the bookkeeper is such that he will naturally figure his costs in the same manner as he keeps his accounts, and thereby often lose the sense of proportion of costs. Costs are really tied up just as closely with the engineering and estimating departments as with the accounting department. The cost accountant should understand the physical side and be able to visualize the work itself,—a thing which a bookkeeper can seldom do.

Three Functions of a Cost Accounting System.—The three functions of any cost accounting system are, first: to aid in assuring the economical handling of the work while it is in progress; second, to obtain figures to compare with the estimate; and last, to supply data for use in estimating future work. These are given in order of their importance.

Costs must be available just as soon as possible to be effective in aiding economical handling of the work. Delayed reports of costs are practically useless in effecting any savings while the work is in progress.

Each morning the labor costs of the previous day should be known. This is not necessary or feasible on all items of work, but on such as concrete, excavation, brickwork, etc., it is possible and extremely important that the superintendent of a job should know the daily labor unit costs. If he has them he can take up with the foreman at once any variations betwen estimates and actual performance, and endeavor to equalize disproportionate costs of any unit before it is too late. Prompt cost reports enable him to comment intelligently on various items before they become past history, and to be certain that both he and his foreman understand just what constitute matters of major importance from the costs standpoint.

Only the direct labor on any operation should be included in these daily cost figures. That is, plant, overhead, etc., should be reported separately and not included with the direct labor charges.

By regular comparison between the actual costs obtained and the estimate, and by means of comparative statements (which form will be explained later) made weekly and monthly, overruns or savings on the estimate may be discussed with the owner at once and he may be kept informed as to just how the job stands financially. This is particularly important on percentage cost-plus work as it permits contractor and owner to get together and talk over the progress of the costs and, if necessary, to make intelligent changes of plan while the work is under complete control and the financial bearing of changes is understood.

Estimate at Start of Job.—At the start of a job an estimate is made in the usual manner. This shows the actual take off from the plans with the items, quantities, units and amounts. These units including the labor, material, overhead and plant costs.

The estimate is then split into a labor and a material analysis. In the labor analysis these various items will show only the direct labor with plant labor and overhead separated.

Opposite each item in the labor analysis is shown the symbol under which the working time is to be reported. These analyses are sent to the job, where they become the standard for the comparisons on all operations of the job and the estimate is not referred to.

Material is carried separately on the other analysis. Thus we have two distinct analyses, one covering the labor directly chargeable to an item, together with the general items of labor; and the other the material items.

One can readily see that, by separating labor and material the work for the job superintendent in following his cost has been made much easier. He knows by the labor analysis just what figures the estimating department has set for the unit of each item. He is able to study his labor costs without being obliged to figure out his material, for the cost of which he is very often not responsible, as a great deal of the purchasing may have been done at the home office. He has condensed for him now those units for which he is responsible. If he thinks any of them too low, he can take up the case at once with the estimating department —and I must confess that this is done quite often.

Aberthaw Timekeeping Symbols.—Most contractors use a series of numbers for reporting their labor operations, but Aberthaw uses an economic code. When I first began to use these symbols I must admit that they seemed almost as difficult at Latin did years ago. I had been accustomed to the numbers for some time and had never thought of reporting concrete or brick by letters. However, it very soon became evident to me that the letter is the much better system.

In the Aberthaw system the first letter is always a capital and indicates the kind of work to be done. For instance F. stands for forms, R. for reinforcement, B. for brick, D. for digging, etc., in so far as possible the first letter of the item represented being used. The second letter is always a vowel and explains the class of work. "a" stands for making item, "e" for erecting or setting up, "i" for tearing down or dismantling, "o" for repairing, "u" for unloading. The third letter which is always a consonant, indicates the part of the building in which the work is being executed, as "f" floor; "w" walls; "c" columns, "s" stairs.

As the code is the same on all jobs, our timekeepers and cost men quickly adapt themselves to any requirements of the work. If some work comes up not included in the code, a timekeeper can very quickly make up his symbol to cover it, and it can usually be interpreted by the cost man. If necessary an explanation may be written opposite the item the first time it is reported.

A real feature of this code is the manner in which it helps visualize the work. For instance, with numbers one might have 21.1 as a symbol for erecting brick walls. How much better is the symbol Bew, "B" brick, "e" erect, "w" walls.

Timekeeper's Field Sheet.—To report the time and distribution of the men the timekeeper uses a field sheet which shows each man's number in the left hand column.

These sheets are in two series, one running from 0 to 50, and the other from 51 to 100, and the numbers are printed on the sheets, so that if a job has a series of checks numbered from 1,200 on, the timekeeper needs only to write in the number 12.

The next columns show the time the men reported for work and the time at which they quit work.

Then there are eleven columns, each one representing one hour's work, and headed 7-8, 8-9, 9-10, etc., up to 5-6. In these spaces, after each man's number is written the symbol for the type of work performed. If one man is erecting forms from 7 to 12 continuously, the symbol Fef would appear in the first hour column and a dash in each succeeding column up to 12 o'clock. Then he might change and work at erecting wall forms to 5 o'clock. In this case the symbol Few would show. The timekeeper makes four checks a day, and if the men have changed their class of work between his checks, he confers with their foreman as to how the hour when changes have been made. The last columns show the man's rate, then the amount earned, and the last two columns his actual hours divided into regular and overtime.

We have, therefore, on this timekeeper's field sheet, a complete record of each man's daily time and amount earned.

Waste Sheet.—The office cost man with the timekeeper's field sheets before him, now uses a sheet which is called a "Waste Sheet." He combines all the Fef, Med, and Ref, etc., symbols on the field sheet and figures the total daily expenditure under each symbol. These amounts he enters each in a column headed with its proper symbol. The total should check with the total daily payroll.

The "Waste Sheet" is ruled for seven days and has spaces for writing in the job symbols. This is kept up to date daily so that at the end of the week the cost man has the total weekly expenditure for all the symbols under which the work has been performed. The quantity man gives him the quantity of work accomplished, which he enters under the total weekly cost of the "Waste Sheet" and then figures the unit cost and writes that under the quantity. He then has under each symbol the total weekly expenditure, weekly quantity, and weekly unit.

Labor Cost Record—The next step is to transfer these items to the unit cost record book. This is a loose leaf I.P. ringer binder carrying a sheet for each symbol. The first column of the sheet shows the date of the week ending; the second the weekly cost, the third the weekly quantities, and fourth the weekly unit. The items take up about one-half of the sheet. The other half shows the cost to date, quantity to date; and unit to date. As a partial check on these items there are included two columns; one for number of barrels of cement used, and one for c.f. of concrete per barrel. At the top of the sheet directly over the quantity, amount and unit to date column is a space to write in the estimated quantity, amount and unit, so that these estimated figures can be compared at any time.

The book is kept up to date each week and is checked against the total payroll of the job.

Labor Cost Statement.—We are now ready to make out the weekly labor cost statement.

In this first the symbol is shown, then the kind of work, next the weekly cost and weekly unit. Succeeding columns offer a detailed comparison with the analysis of estimate, the estimated quantity unit and cost being set against the actual quantity and unit and cost attained in operation. The last two columns give opposite each item in one case the overrun; in the other the saving.

As an illustration: suppose we have listed in our analysis of estimate 100 cu. yd. of concrete under the symbol Med at a unit cost of $1.50 per cubic yard. By the 5th week of the job there has been completed 700 cu. yd. at a unit cost of $2 per cu. yd. Seven hundred cu. yd. at $1.50 would be $1,050, which would have been the expenditure on that item, provided the work had been done at the estimated unit of $1.50. But actual cost is $2 per cu. yd. which means an expenditure of $1,400 or an overrun of $350, on this item. If it had been done for a unit of $1.00, there would have been a saving of 50 cents per cubic yard, or a total saving to date of $350. Each item is figured out similarly and the difference between the saving and overrun is shown in a proper column.

For those items on which no quantity is reported, as plant, watchman, overhead, etc., a percentage is used. For example, if $1,000 is allowed for overhead and the job is to last ten weeks, this overhead will average $100 per week. If after the job has gone six weeks and $700 has been expended, and it is figured that $450 more will be expended, the overrun will be $150; and this is shown.

The labor cost sheet gives the costs in detail for the job superintendent to study and informs him just where he should concentrate and what he should study. If 75 per cent of his total overruns is in two items, the place for him to remedy his high units is clear. Without some such data how can a superintendent intelligently talk to his foreman or know his job?

Labor Comparison.—In order to condense this report for the management, a comparison of the savings and overruns is made, listed under the various symbols. All the concrete overruns or savings on one class of work are totalled and the total overrun or saving shown. The record of previous weeks is also shown so it may be compared with that of the current week.

The labor cost statement, together with this summary sheet attached, is sent into the main office each week so as to reach there not later than the Monday morning following the closing of the payroll. One copy goes to the general superintendent and one to the cost department.

Payroll Sheet.—The payroll sheet is ruled for seven days, with two columns for each day—one to show regular and the other overtime hours. The regular and overtime hours are extended and shown in separate total columns as also is the regular and overtime rate. The total amount earned for the week being in the next column. The man's name and number appear in the extreme right hand column. This, I think, is rather unusual, but we find it much better when paying off, as the person paying need only look to the next column and not from one side of the sheet to the other which lessens the danger of errors considerably.

So much for the labor cost records. Their handling is so standardized that we can transfer our cost men if necessary to any job, and they can readily pick up another timekeeper's or cost man's duties.

Purchase Order.—The first form necessary, of course, for material records is the purchase order. This form is made to give all the necessary information and to show what the material is to be used for, which gives the cost man his distribution.

Material Received Form.—On receipt of the material it is checked and entered on the daily material received form, showing the order number, vendor and material. On receipt of an invoice it is checked against this material received sheet for receipt of the goods.

Invoice Record.—When the invoice has been approved and passed for payment it is entered in the invoice record. There is a page here for each vendor and all payments made are entered, showing the invoice number, commodity and amount. In the right hand columns are shown the check number with which the invoice was paid, date and voucher number. The last column shows the statement number on which the invoices appeared when the month's expenditures are reported to the owner.

A page is also used for the weekly payrolls and this register should check with the total of the labor and material cost books.

Material Cost Record.—The material cost record consists of a loose leaf I.P. binder book. In it each item in the material estimate has a page and the estimated quantity, amount and unit is entered at the top of the sheet. After the invoices for material have been checked and paid, they are entered in the material cost record. The date of the invoice, vendor's name, kind and amount of material, and cost is entered.

There is also a column headed "outstanding orders" and the amount of an order, as soon as it is placed, is shown in this column in pencil. As payments on these orders are made they are entered in ink in the amount column and the outstanding order figure reduced, correspondingly. The next column is for credits and the last shows the total cost.

This book, then, contains all amounts paid for material on the job and the total of this book and the labor cost record at the completion of the work must check with the total cost as shown in the bookkeeper's ledger.

Material Cost Statement.—In order to know how our purchases for material compare with the analysis of estimate, we make each month a material cost statement similar to our weekly labor cost statement and show the overruns or savings on each item.

This form shows the item first, then the estimated and actual quantity, estimated and actual unit and estimated actual cost. In the next column is entered the outstanding orders. In the estimated quantity column is entered the total quantity as shown in the analysis of estimate and in the actual quantity column the quantity actually paid for.

This statement is made to show as nearly as possible not only what the overrun is at the time the statement is made. but as nearly as possible the final overrun or saving.

Of course, on the first three or four statements on a job that will take ten months to complete, this is not possible, as all purchases will not be made or all contracts let, but in a very short time this comparison will indicate quite clearly the saving or overrun on the material costs that will show at the completion of the work. In addition to the outstanding orders being shown we also estimate salvage and credits on plant, form lumber, etc., and include these figures in our statement.

Three copies of this monthly material statement are made. Two copies are sent the home office, one for the general superintendent and one for the cost department. The third copy is for the job files.

Graphic Method of Tabulating Job Cost.—The purpose of this graphic chart is to place before the manager the status of the job and enable him to quickly pick out these items which are above the estimate and need special attention. This chart shows what the final overrun or saving will be on the various items if the unit obtained to date is maintained for the remainder of the work.

A valuable feature of this chart is that the quantity of work influences the tabulation, thereby showing that a small overrun on a very large quantity would result in a much larger money overrun at the end of the job than a large overrun on a small quantity of work. This would indicate that the large quantities of work to be performed should have the first attention in getting low unit costs.

On our labor cost statement you will remember we show the saving or overrun to date on the various items of work. Any seemingly small unit overrun on this labor statement would not always cause serious comment on the part of the job superintendent or management, but on these charts this small unit overrun, if it applied to a large quantity of work would result in a very large money loss at the end of the job.

Plotting these costs each week, directly under the previous weeks, shows any variations and can be easily studied, compared and acted upon immediately before it is ancient history and too late to do any good.

Final Cost Summary.—At the completion of the job and after all bills have been paid the final cost summary is worked up. The labor, material and plant units are shown separately and each divided into two or more items and the total unit and total cost obtained.

These summaries are blueprinted and a copy furnished the estimating department. Attached to this summary is a job history giving information regarding the personnel, prices paid for cement, sand, brick, etc., nature of the soil, list of subcontractors, wages paid labor, how concrete was distributed, whether by buggy or chutes, number of towers and height, etc., etc.

The quantity man, of course, has to keep in very close touch with the timekeeping and cost department. He reports the quantities under the symbols as shown on the analysis of estimate and must keep these right up to date, in order to insure the cost statement being completed promptly.

On small jobs the reporting of quantities will be done by the engineer, but on large operations one man will be assigned to do this work. Without good accurate quantities up to date at all times the cost data are, of course, practically useless.

Cost Comparisons.—In order to stimulate interest among our foremen we have been making up at the home office weekly comparative cost statements showing the units obtained on various jobs for similar classes of work. On this comparison we show the bogey unit allowed each job on the items compared, the quantity done and the unit obtained on the job. Under each job we show the superintendent and foreman's name and those foremen whose units are below bogey have a star opposite their names. We find that these comparisons arouse interest and some rivalry. I have had letters from foremen regarding these units with the complaint that they do not understand how foreman so and so can be getting the costs shown on this job, and with a request I investigate as to whether any first rub has been included in the concrete unit, etc.

Organization.—The organization of one of our jobs for say a $500,000 operation would be as follows:

A chief office man who would be responsible for all the office work, and who would sign all checks in payment of invoices and payrolls. A material clerk whose duty it would be to check and approve all invoices for payment and to enter these invoices in the material cost book and invoice register. A labor cost clerk who makes the weekly labor cost statements and the payroll. A timekeeper checking the men in and out and making four checks daily on the job, and an outside man checking the receipt of all material and entering it on the material received form daily. On large jobs this same set-up would hold, but would be increased by assistants to these men. There is no clerk here working exclusively on costs, as the cost clerk is also responsible for the payroll figures.

Accumulated Deficiency in Building Construction

Its Magnitude, Where It Is Most Acute and Prospects for Construction Told in Article in The Constructor

By LEONARD P. AYRES,
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There are no official statistics compiled in this country to show the amount of building in progress or projected from month to month or by yearly totals. There are several compilations of the amounts of building permits granted by municipalities, and the F. W. Dodge Co. of New York publishes monthly reports of contracts awarded in 27 States. For the present purpose data were needed showing the amounts of building undertaken in the same localities over a long series of years, for only by using such figures can trustworthy inferences be reached as to the approximate shortages of building in any given years.

Accordingly figures have been compiled by the writer giving the amounts of building permits granted in 50 cities during the past 22 years. Most of these data were taken from the reports of the U. S. Department of the Interior. Where it was possible to secure missing data from the files of Bradstreet's that was done, and in the remaining cases the figures were secured through corresponding with the building departments of the cities concerned. These cities from which the building permit figures have been secured for each year from 1900 through 1921 are the following:

New England:
- Boston
- Cambridge
- Fall River
- Hartford
- Lowell
- New Bedford
- New Haven
- Providence
- Worcester

Middle Atlantic
- Buffalo
- Jersey City
- Newark
- New York
- Philadelphia
- Pittsburgh
- Reading
- Rochester
- Scranton
- Syracuse

Western
- Denver
- Los Angeles
- Oakland
- Portland
- San Francisco
- Seattle

East North Central
- Chicago
- Cincinnati
- Cleveland
- Columbus
- Dayton
- Detroit
- Grand Rapids
- Indianapolis
- Milwaukee
- Toledo

West North Central
- Kansas City, Kans.
- Kansas City, Mo.
- Minneapolis
- Omaha
- St. Joseph
- St. Louis
- St. Paul

Southern
- Atlanta
- Baltimore
- Louisville
- Memphis
- Nashville
- New Orleans
- Richmond
- Washington

Building permit figures are only relatively trustworthy indicators of the amount of building actually done. In some cases permits are secured and later on the project is given up. More frequently the final costs of the building are greater than were expected and so the permit figures are too low. These inaccuracies tend in some degree to counter-balance one another. A more important consideration, however, is that, while permit figures probably understate the cost of the buildings actually completed, they almost surely have in the long run an approximately steady and reliable relationship to the actual costs, and so constitute good measures by which to infer the amounts of shortage or surplus of the construction actually carried through to completion.

The upright columns of Fig. 1 indicate the number of millions of dollars' worth of building permits granted in the 50 cities each year from 1900 through 1921. These cities had an aggregate population of 15,231,000 in 1900, which increased to 24,994,000 in 1920. They include nearly one-fourth of all the people in the country.

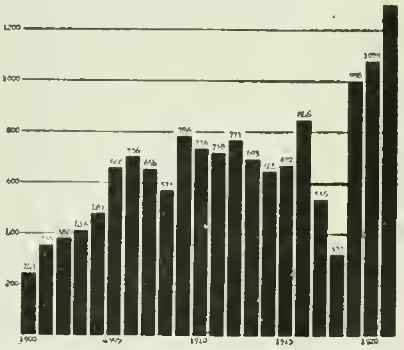

Fig. 1—Millions of Dollars Worth of Building Permits Granted in 50 Cities Each Year From 1900 to 1922.

The figures show a rapid growth in permit value from 243 millions in 1900 to 706 millions in 1906. Then there was a decline in the value of building operations during the depression of 1907 and 1908, followed by a recovery and later on by another decline in the depressed years of 1914 and 1915. The abnormally low volume of building operations in 1917 and 1918 is clearly shown, as well as the high figures reached in 1919, 1920, and 1921.

Cost of Building.—The figures showing the number of millions of dollars' worth of permits granted each year do not accurately indicate the relative amounts of construction actually undertaken, for during this period the costs of building varied greatly, and the high figures of the three years following the war do not represent anything like as many houses, stores, and factories as they would have if this building had been done at the much lower costs that prevailed a few years earlier.

In order to make adjustments for these varying costs an index number of the cost of building has been worked out, and as a matter of interest it has been carried back all the way to 1840. It attempts to show about what the relative cost of building would have been in each year over this 82-year period if we take the cost in 1913 as being represented by 100.

In constructing this index number for the cost of building it has been assumed that in the typical construction operation the expense for materials is 60 per cent of the total, and that for wages, 40 per cent. In computing labor cost the wages of the building artisans have been given twice as heavy a weighting as those for building laborers.

This index is one originally worked out by the Federal Reserve Bank of New York for the years from 1913 to 1922 and carried back by the present writer to 1840. The data from 1840 to 1890 are taken from the Falkner report made to the U. S. Senate Committee under the chairmanship of Senator Aldrich. The later figures are from the reports of the U. S. Department of Labor.

The data for the cost of materials are those used for building materials by the United States Bureau of Labor Statistics, modified by the inclusion of cost figures for metals and metal products since 1890, to allow for the increasing use of structural steel in building construction. These metal figures were given a weight of only 2 per cent of the whole cost for building materials in 1891 and increased by two points each year up to 1900, since which time they have been given a weight of 20 per cent each year.

The results of combining all these figures over this long span of years are shown in Fig. 2, in which the upper dashed line shows the course of material prices, the lower dotted line that of wage costs, and the solid line the cost of building in each year from 1840 through 1921. The costs for each year are expressed as relative to the costs in 1913, if those are represented as 100. Beginning in 1840 the cost of building ran along for about 20 years at a level slightly above 50. That is to say, that during these years building was only a little more than half as costly as it was in 1913.

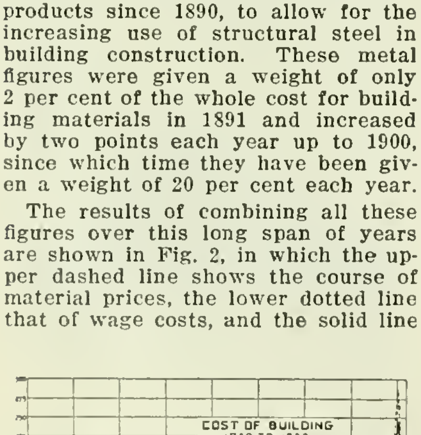

Fig. 2—Cost of Building From 1840 to 1922.

Then in 1861 came the Civil War and a great increase in the cost of materials, which carried the cost of building up to nearly two and a half times what it was just before the war. From this high point the cost of construction fell rapidly, with one notable interruption, for some 15 years. It then ran along without important fluctuations for 20 years more, and then began the long rise from 1898 to 1915. With the advent of the war with Germany the prices of materials, the costs for wages, and the level of building costs shot up until the peak was reached in 1920.

It is interesting to note that the increase in the cost of building during and following the World War was relatively only slightly greater than that which occurred during the Civil War. From 1860 to 1864 the cost of building increased by 136 per cent, and in the first year after the peak of prices the decline was 12 per cent.

In the case of the World War building costs increased from 1914 to 1920 by 153 per cent, and then fell in the first year of decline 24 per cent. Thus it appears that both the increase and the immediate decline in building costs have been somewhat more violent this time than in the case of the Civil War, but not much more. It would be interesting to speculate on the probability that building costs may continue to decline irregularly over a long period of years to come, as they did after the Civil War, but this does not fall within the province of the present report.

Computed Cost of Building by Years.—The figures showing the computed cost of building each year are given in Table 1. This table must be used differently from the ordinary one. The first number in the body of the table is 55.3, and this indicates that the relative cost of building in 1840 was 55.3. In 1841 it was 56.2, in 1842 it was 55.1, and so on down the column. The 10 numbers of the column are the cost of building data for the decade beginning in 1840, and the year of the decade is indicated by the numbers from 0 to 9 in the column at the extreme left. To find the cost of building in 1865 one would look at the number in the row opposite 5, and in the column entitled "1860 to 1869." The number opposite 5 in that column is 112.3.

TABLE 1.—RELATIVE COST OF BUILDING SINCE 1840 IF COSTS IN 1913 ARE TAKEN AS 100

Final figure of date	1840 to 1849	1850 to 1859	1860 to 1869	1870 to 1879	1880 to 1889	1890 to 1899	1900 to 1909	1910 to 1919	1920 to 1929
0	55.3	52.5	53.6	88.3	70.7	69.2	75.1	98.9	247.1
1	56.2	50.6	60.7	88.8	72.1	68.3	76.3	97.6	189.0
2	55.1	51.9	77.5	93.2	74.5	66.4	79.2	97.6	
3	54.5	53.5	94.1	93.5	72.0	68.9	81.7	100.0	
4	62.7	58.3	126.6	87.7	70.7	64.4	82.1	97.6	
5	54.3	54.3	112.3	81.1	70.0	64.2	85.6	97.8	
6	54.0	54.4	105.9	77.0	71.8	64.4	92.4	108.1	
7	55.6	55.6	103.8	71.8	69.7	63.4	96.8	128.1	
8	54.6	54.8	100.9	65.7	69.8	65.3	91.4	143.2	
9	51.3	53.3	100.1	66.2	69.7	73.1	91.7	170.9	

These data for the cost of building are probably fairly accurate indicators of the varying cost of general construction in the country as a whole over the years indicated. They are almost surely better measures of the cost of building residences and small commercial buildings than for large industrial and office building construction.

Since the construction of this index, the United States Bureau of Labor Statistics has issued a new index number for the cost of building materials that is very different from the one that it has hitherto published.

It is based on more kinds of materials priced in a wider range of markets, and it gives greater weight to metals. Its weightings are based on the relative amounts of production of the different articles in 1919 instead of in 1909, as were those of the old index.

Because of the interest that exists with regard to the varying cost of building, the two indexes, based on the old figures of the Bureau of Labor Statistics and on the new figures, have been worked out by months since 1913. The figures using the old data for material costs are presented in Table 2, and those using the new data are given in Table 3. The old series has been used throughout the present study. In the opinion of the writer, it gives results that are reasonably trustworthy as showing the changes in the general cost of building. Its figures for 1921 and 1922 are probably somewhat high.

TABLE 2.—COST OF BUILDING BY MONTHS, USING OLD SERIES OF MATERIAL PRICES

	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
January	100	98	96	104	115	131	149	218	211	181
February	101	99	97	105	117	133	150	247	202	184
March	101	99	97	107	119	136	150	251	197	182
April	101	99	97	108	121	137	148	261	191	.
May	101	98	98	109	125	140	153	263	189	
June	101	98	98	108	131	143	163	261	186	
July	100	98	98	107	138	146	169	260	184	
August	99	98	97	107	138	148	181	258	181	.
September	99	97	97	108	136	150	191	253	180	
October	99	97	98	109	131	150	193	250	180	.
November	99	96	99	111	130	154	197	230	182	.
December	98	96	101	115	131	152	208	224	185	
Average	100	98	98	108	128	143	171	247	189	.

The new data are probably more nearly trustworthy than the old ones. In so far as the results of this study are concerned, it makes little difference which series is used. Computations utilizing the old series result in an indicated shortage slightly greater than would be the case if the new figures were employed. It is interesting to note that, according to these new figures, the increase in the cost of building during the recent period of high prices was relatively no greater than it was during the corresponding period of the Civil War.

Volume of Building on 1913 Cost Basis.—By using the figures of Table 1 it is possible to revise the permit figures for the 50 cities, so as to show the relative value of the construction that would have been done in each year if the cost of building had remained constantly at the 1913 level. Thus the first column of Fig. 1 shows that the value of the permits issued in the 50 cities in the year 1900 was 243 million dollars. But Table I shows that the cost of building in that year was only three-fourths as great as it was in 1913. This means that, if the volume of new construction actually undertaken had been paid for at the 1913 prices, it would have cost four-thirds as much money, or 324 million dollars.

TABLE 3.—COST OF BUILDING BY MONTHS, USING NEW SERIES OF MATERIAL PRICES

	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
January	101	96	94	107	125	112	157	232	193	167
February	101	96	94	109	126	142	155	246	186	166
March	102	97	95	112	129	144	154	250	182	165
April	102	96	95	114	136	147	153	254	177	165
May	102	96	97	114	139	150	160	252	175	168
June	101	97	97	114	145	152	173	241	171	
July	99	96	97	114	148	156	186	238	169	
August	99	97	97	114	145	158	197	236	167	.
September	99	96	98	117	145	159	200	231	167	
October	99	95	100	116	139	157	200	222	160	
November	98	94	101	118	139	157	203	207	171	.
December	98	94	104	121	140	157	215	200	168	
Average	100	96	97	114	138	152	180	231	175	..

In a similar way the figures of each column of Fig. 1 can be converted to the 1913 price basis, and, when this is done, the results are those that are shown in Fig. 3. This diagram is simply the first diagram converted to the 1913 price basis, and, since actual prices were lower in the first part of the period and higher in the latter part than in 1913, the columns of the diagram presenting the earlier years are increased in height, and the latter ones are shortened, just as that for 1900 was increased when converted to the 1913 base.

Building Per Capita of Population.—The columns of Fig. 3 show the volume of new building, as measured by its value, that was undertaken in these 50 cities over this 22-year period after the costs have all been put on the 1913 price basis. They show a rapid increase over the first six years, an irregular fluctuation around a level at about 700 millions for about 12 years, and a clearly evident shortage during the war years and those since the war.

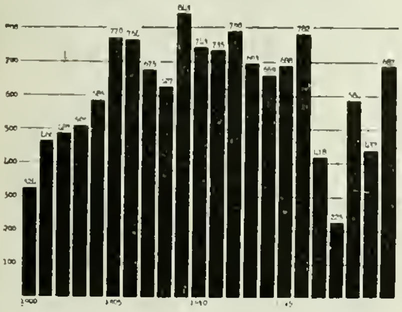

Fig. 3—Millions of Dollars' Worth of Building Permits Granted in 50 Cities Each Year From 1900 Through 1921, After Figures Have Been Converted to What They Would Have Been If Costs of Building Had Been at the 1913 Level During Entire Period.

It is to be remembered, however, that the population of these cities was increasing rapidly during this period. It was about 15 millions in 1900 and about 25 millions in 1922. A year by year comparison will be more trustworthy if the figures are converted once more to show what the amount of building was per capita of the population.

The results of this new computation are shown in the columns and figures of Fig. 4, which indicate the number of dollars' worth of new construction under taken each year for each person in the populations of these cities. The 1913 cost basis is used throughout and the populations have been carefully estimated for each of the years between the census years.

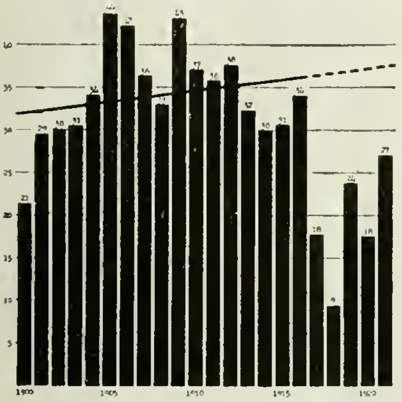

Fig. 4—Value of Building Permits Per Capita of Population for 50 Cities Each Year From 1900 Through 1921 After Data Have Been Converted to 1913 Cost Basis. Straight Line Shows General Trend From 1900 Through 1916.

In 1900 the value of new building undertaken was $21 per person, as is shown by the first column of the diagram. It rose rapidly until it reached $44 in 1905 and then fluctuated until 1916, when it was $34. At this point the serious shortage began to develop. In 1917 the per capita amount fell to $18, and in 1918 to $9. The three years since then have shown increases, but the totals have been far below normal amounts.

Running through Fig. 4 there is a heavy slanting line. This indicates the estimated normal amount of building over this period. It is a line drawn by the mathematical method of least squares, and it is based on the data for the years from 1900 through 1916. It may be defined as a line that represents more accurately than could any other line that might be drawn the general trend of the irregular series of amounts indicated by the columns for the years from 1900 through 1916. At its right-hand end this line has been extended in a dashed line, and the difference between the columns from 1916 on and the height of this line above the base is taken to show the amount of the existing building shortage at the beginning of 1922. The detailed figures on which the diagrams for the 50 cities are based are given in Table 4.

TABLE 4—VALUE OF BUILDING PERMITS IN MILLIONS OF DOLLARS IN 50 CITIES EACH YEAR FROM 1900 THROUGH 1921, THEIR VALUE CONVERTED TO THE BASIS OF THE COST OF BUILDING IN 1913, AND THEIR VALUE PER CAPITA OF POPULATION EACH YEAR ON THE 1913 COST BASIS

Year	Value of building permits (millions)	Value of building permits on 1913 basis (millions)	Per capita value of permits on 1913 cost basis
1900	243.3	324.0	$21.27
1901	355.4	465.8	29.64
1902	385.7	487.0	30.07
1903	415.5	508.6	30.48
1904	480.5	585.2	34.09
1905	659.5	770.4	43.64
1906	705.6	763.7	42.10
1907	653.7	675.1	36.26
1908	572.6	626.5	32.78
1909	786.2	842.6	42.99
1910	735.8	743.2	37.00
1911	718.0	734.9	35.72
1912	770.5	789.5	37.48
1913	693.4	693.4	32.17
1914	643.7	658.8	29.88
1915	671.9	687.7	30.52
1916	845.7	782.3	34.07
1917	535.7	418.2	17.78
1918	321.9	224.9	9.37
1919	998.4	564.2	23.84
1920	1079.3	436.8	17.48
1921	1298.9	687.2	26.96

Shortages by Geographical Groups.—The records for the different individual cities have been brought together by groups in Fig. 5. Here the per capita expenditures for each year are represented by the upright columns, while the trend lines are shown as in the other diagrams. The indicated shortages are represented by the shaded areas filling in the space between the columns showing the actual construction of the last six years and the trend lines showing the computed normal volume of building for that same period. The shortages range from 1.9 years in the Middle Atlantic States to 3.0 years in the Western group.

In three of the groups of cities the general trend line slants upward, while in the three remaining groups it slants down. In Fig. 4, which showed the per capita construction for the entire group of 50 cities, it slanted up, and a study of the individual diagrams will show that in 18 cases the trend is down, and in practically all the remaining 32 it is up.

It is not difficult to explain the general tendency for the per capita expenditures for new building to rise, even after the figures of permit values have been converted to a constant cost basis, which is in this case that of 1913. This tendency to increase apparently reflects the rising standard of housing in this country which manifests itself in business, industrial, and public building, as well as in residence construction. During the past 25 years a new type of dwelling house has come into existence in this country. It has hardwood floors, steam heating, modern plumbing, electric lighting, and a completely finished basement. In ever-increasing measure these features are being incorporated even in the houses occupied by people of the most modest incomes, while every growing city is becoming surrounded by suburbs largely consisting of houses far surpassing in beauty, convenience and elegance all except the very finest houses of a few decades ago.

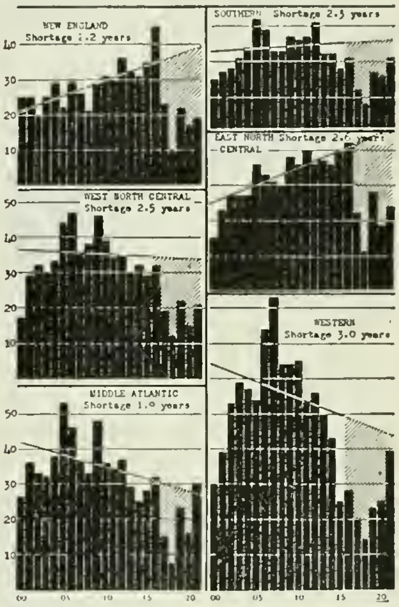

Fig. 5—Six Groups of Cities. Per Capita Value of Permits Shown by Columns, General Trend Based on Pre-War Records and Shown by Straight Solid and Dotted Lines, and Computed Shortage of Building Shown by Shaded Areas.

Similar changes in accepted standards are taking place in our office buildings, factories, schools, theaters and public buildings. The general standards are rising, and, as the public taste is educated to demand more, the average level of expenditure per person goes up.

TABLE 5—INDICATED SHORTAGE OF BUILDING CONSTRUCTION IN 50 CITIES AT BEGINNING OF 1922. THE SHORTAGES ARE RECORDED BY YEARS, TAKING AS ONE YEAR THE VOLUME OF CONSTRUCTION ESTIMATED AS NORMAL FOR EACH CITY FOR 1921

City	Rank in descending order	Years of shortage	City	Rank in descending order	Years of shortage
Atlanta	23	2.4	*Nashville	49	1.2
Baltimore	12	2.8	Newark	42	1.7
Boston	35	2.0	New Bedford	24	2.4
Buffalo	20	2.6	New Haven	10	3.0
Cambridge	43	1.6	New Orleans	45	1.3
Chicago	4	3.2	New York	33	2.1
Cincinnati	5	3.1	Oakland	22	2.5
Cleveland	39	1.7	Omaha	28	2.2
Columbus	36	2.0	Philadelphia	37	1.8
Dayton	46	.8	Pittsburgh	34	2.1
Denver	8	3.0	Portland	1	3.5
Detroit	40	1.7	Providence	38	1.8
Fall River	32	2.1	*Reading	48	.2
Grand Rapids	15	2.7	Richmond	29	2.2
Hartford	41	1.7	Rochester	3	3.3
Indianapolis	25	2.3	St. Joseph	18	2.7
Jersey City	13	2.8	St. Louis	19	2.7
Kansas City, Kan	47	.3	St. Paul	30	2.2
Kansas City, Mo	16	2.7	San Francisco	2	3.4
Los Angeles	14	2.8	Scranton	26	2.3
Louisville	9	3.0	Seattle	6	3.1
Lowell	50	2.2	Syracuse	7	3.1
Memphis	17	2.7	Toledo	31	2.2
Milwaukee	27	2.2	Washington	44	1.6
Minneapolis	21	2.6	Worcester	11	2.9

It is harder to explain why it should not show this rising tendency in practically all the cities, instead of in only about two-thirds of them. The most important element of the explanation is undoubtedly to be found in the varying rates of growth of the different cities.

If a city should have a stationary population over a long period of years, it would require new building construction only for the purpose of replacing old buildings when they become unsuitable for further use, or the occasional erection of some new structure required by some such modern development as the automobile. Clearly, such a city would have a low per capita construction record. On the other hand, cities that grew with such unparalleled rapidity as did those of the far west from 1900 to 1910 required for a time a much greater per capita expenditure than they could over a long term of years.

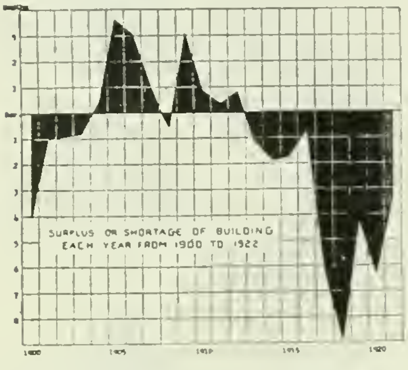

Fig. 6—Months of Surplus Over Normal or Shortage Under Normal of Buildings in 50 Cities From 1900 to 1922.

Range of Average Values.—There is a great range in the annual average value of the new construction undertaken for each person in the population of these cities. Over the pre-war period, which is, in most cases, the 15 years from 1901 through 1915, the city of Lowell, Mass., has an average yearly per capita expenditure of $12.07, while at the other extreme is Los Angeles, with an average of $64.31. The average of these figures for the entire 50 cities is $30.84.

These figures are given in Table 6. It will be noted that the cities having the lowest averages are largely mill cities, or Southern cities. Those having the highest figures are mostly cities which are located in the far west, and have had exceptionally rapid growths. The average for New York City, where the amount of construction is so enormous that its value in many years is more than one-half as great as that for the other 49 cities combined, is relatively high. It amounts to $43.44, and in only seven cities is the average higher than this.

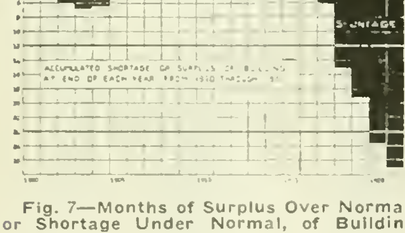

Fig. 7—Months of Surplus Over Normal, or Shortage Under Normal, of Building in 50 Cities. Diagram Shows the Amount Accumulated to the End of Each Year From 1900 Through 1921.

Shortages and Surpluses.—The per capita value of permits on the 1913 cost basis was shown for the 50 cities in Fig. 4. Through the upper part of that diagram there was drawn a slanting line showing what the normal construction in each year would have been if the general trend of the pre-war years had been continued over the entire period. In that diagram this trend was based on the actual data for the 17 years beginning in 1900 and running through 1916.

For the first four years the actual amounts were under the computed normal, as indicated by the trend line. During the next nine years the actual amounts were above the computed normal, except in 1908, which was a year of severe business depression. All the other years show deficiencies, but not serious ones, until we entered the war in 1917. From that point on building construction was clearly far below normal.

Since we have these actual records, which are in each case below or above the theoretical normal amounts for the same years, it becomes a simple matter to construct another diagram in which the computed normal is represented as a level line, and the shortages and surpluses are shown below or above that line for each year. This has been done in Fig. 6. The values of the diagram are in terms of months. In 1900 the actual construction was only two-thirds of the estimated normal, so there was a shortage equal to the construction that would normally have been undertaken in one-third of a year, or four months. In each of the three following years there was a shortage equivalent to the normal construction of about one month. After that there were surpluses for four years. By these same methods the shortages and surpluses are shown over the entire period. In 1918, when the Government restrictions were in force, the actual construction was only about one-fourth of the computed normal, so there was a shortage of nearly nine months in the amount of building undertaken.

TABLE 6.—YEARLY AVERAGE PER CAPITA VALUE OF BUILDING PERMITS ON 1913 COST BASIS IN 50 CITIES FOR THE PRE-WAR PERIOD FROM 1901 THROUGH 1915

City	Average	City	Average
1 Lowell	$12.07	26 Milwaukee	$30.27
2 Fall River	12.60	27. Indianapolis	30.33
3 New Orleans	12.87	28 St. Louis	30.51
4 St. Joseph	14.47	29 Boston	31.73
5 Reading	14.86	30 Pittsburgh	32.82
6 Kansas City, Kan.	15.50	31 Newark	33.19
7 Baltimore	16.00	32 Detroit	33.20
8 Nashville	18.07	33 Memphis	33.80
9 Scranton	18.27	34 Denver	34.43
10 Louisville	18.47	35 New Bedford	34.54
11 Jersey City	19.27	36 Omaha	34.93
12 Grand Rapids	21.87	37 Chicago	36.73
13 Buffalo	22.07	38 Atlanta	36.87
14 Cambridge	23.31	39 Rochester	38.54
15 Toledo	23.67	40 Washington	38.87
16 Dayton	24.00	41 Hartford	41.80
17. Philadelphia	25.07	42 Minneapolis	42.13
18 Providence	25.27	43 New York	43.44
19 Worcester	26.51	44 St. Paul	43.83
20 Columbus	27.20	45 Kansas City, Mo.	50.20
21. Richmond	27.71	46 San Francisco	51.42
22 Syracuse	27.93	47 Portland	52.00
23 Cleveland	28.15	48 Oakland	52.62
24 New Haven	28.13	49 Seattle	57.31
25 Cincinnati	28.47	50 Los Angeles	64.31

If there is a shortage of building each year for several years in succession, a serious shortage accumulates, and it may take several years of more than normal building to wipe it out. This is what appears actually to have happened during the period under consideration, and the course of these accumulations of shortage and surplus is shown in Fig. 7.

Figure 7 is constructed on the theory that there was neither surplus nor shortage of building at the begining of 1900. We do not know that this was the case, but we do know that the two preceding years had been years of business recovery following a depression, and years of considerable building activity. The assumption that building conditions were reasonably in balance at the beginning of 1900 is probably not far wrong.

During 1900 there was a shortage of four months, and this is shown on the diagram by the black column below the normal line. During the following three years this was increased by about one month each year until it amounted to nearly seven months in 1903. It was then rapidly cut down by the active building of the following years until a surplus existed in 1906. This increased to a surplus over five months in 1912, when it began to shrink; and this continued to 1916, when a condition of balance was reached, with neither surplus nor shortage.

Then came the great shortages of the war and the post-war period, and the accumulating deficit grew until it was more than a year by the end of 1918, more than two years by the end of 1920, and 2.44 years by the end of 1921. If this estimate is substantially correct, it means that there exists in American cities an indicated shortage of building construction so great that the building industry could operate at nearly 25 per cent above normal for a period of 10 years before it would entirely make it up.

It is certain that the building industry will not operate steadily during the coming decade at a rate that is 25 per cent above its normal, for that is not the way in which new construction comes into existence. It will have its periods of great activity, as it is now having one in 1922, and it will have dull periods at times when building costs are too high, and at times when business is depressed. It is highly probable, however, that the industry will feel the stimulus of the accumulated shortage for several years, and perhaps for as much as 10 years.

Nature of Shortage.—If we accept it as reasonably well demonstrated that there existed in these 50 cities at the end of 1921 a shortage of building construction approximately equal to the amount that would have been normally completed in about two and a half years, we can estimate from the records of actual construction about how many and what sorts of buildings would have to be erected to wipe out the deficit.

From the building records of these cities for 1920 and 1921 figures have been compiled showing the different kinds of buildings constructed in these years. By using these figures, and assuming that to make up the existing shortage would require more building of substantially the same sort, a rough estimate of the amount of construction still needed becomes possible.

From this estimate it appears that the shortage existing at the beginning of 1922 was such that it would require about 1,256,000 building operations to make it up. Of these operations, about 703,000 would call for the erection of new buildings, while the remaining 553,000 would be for annexes, additions, alterations, etc. Of the 703,000 new buildings, about 303,000 would be residential, and the remaining 400,000 buildings of other sorts. A large majority of these latter buildings would be garages. The 303,000 residential buildings would mainly be one-family houses, but a sufficient number of them would shelter more than one family to furnish accommodations in all for about 424,000 families.

The further one carries such estimates the less reliable they become, but they are of value, because they rest on carefully treated evidence, and are far more trustworthy than mere guesses. In a rough general way, one might estimate the probable shortage of building in the entire country by multiplying by four the figures that have just been cited. The justification for doing this would be found in the fact that these 50 cities include in their populations nearly one-fourth of all the people in the country. Such a series of estimates for the whole country would probably give results somewhat too high, for these cities are growing more rapidly than the country as a whole, and require more new building. They probably restricted construction more than the smaller communities did during the war years, and so incurred relatively greater deficits.

There are two comments that may well be added concerning the material that has been discussed in this report. The first is that not all of any shortage such as those now existing in building construction in our cities has to be made up. Part of these shortages has already been made up through using old buildings longer than they would have been used if there had been no war. Such use is like the extra use that we may have given a pair of shoes or a suit of clothes during the war period. After we had made these garments last a year longer than was normal, we had taken from them a certain amount of service that was a permanent gain and that did not have to be made up. On the other hand, the fact that we had worn them for more than the regular length of time brought us into the market after the war with an insistent demand that could not well be longer postponed. It seems probable that if due allowance were made for the extended use of buildings that would under ordinary circumstances have been replaced some years ago, the estimates of this report would not be greatly changed.

The second comment relates to the reliability of the method of estimating shortages by extending a trend line based on previous records and taking it to represent about what would probably have happened under ordinary circumstances, which means in this case what building would have been done if there had been no war. This method gives valuable and reliable results about in proportion as the material being studied is of such a sort that wide fluctuations do not characteristically take place, and the records extend back over a relatively long period. In the present case the mass estimates for the 50 cities are considerably more reliable than are those for the six geographic groups, and these in turn are much more trustworthy than those for the individual cities.

Summary.—1. Since the outbreak of the war in 1914 a great shortage of building construction has been accumulating in this country.

2. A study has been made of the value of building permits in 50 large cities from 1900 through 1921, and by extending the general trend of the pre-war expenditures an attempt has been made to estimate what the volume of new construction would probably have been if the war had not occurred.

3. The difference between the new construction actually undertaken in the six years from 1916 through 1921, and the amount that probably would have been begun if the war had not intervened, is so great that it is equal to 2.44 times the estimated normal construction for 1921.

4. The existing building shortage in these 50 cities is so great that building could continue at about 25 per cent above its normal activity for 10 years before it would entirely make up the deficit.

5. To make up the indicated deficit in these 50 cities would apparently require about 1,256,000 building operations, of which 703,000 would call for the erection of new structures, and the remaining 553,000 for additions, alterations, etc.

6. Of the 703,000 new buildings, about 303,000 would be residential, and the remaining 400,000 would be buildings of other sorts, of which a large majority would be garages. The 303,000 residential buildings would be largely one-family houses, but a sufficient number of them would shelter more tha none family to furnish accommodations in all for about 424,000 families.

7. Since these 50 cities include in their populations nearly one-fourth of all the people in the country, the figures that have been given may be multiplied by four to give a rough, although probably high, estimate of the building shortage in the entire country.

8. Figures showing the annual course of the cost of building since 1840 indicate that the relative increase and suceeding drop in building costs at the time of the Civil War were similar to the corresponding price movements during and after the World War, but the latter were somewhat more violent.

9. There is a great range in the average annual per capita expenditure for new buildings in these 50 cities. The lowest figure is $12.07 for Fall River, the highest, $64.31, is Los Angeles, and the average, $30.84 for all the cities.

Tests of Structural Steel Welds

How Reliability of Welded Joints Is Determined and Limiting Conditions of Various Types of Joints*

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The intention of this article is not to point out any definite or standard method of fastening together structural parts preparatory to welding, since in the majority of instances the local company—assuming that this work is carried on under a structural superintendent—will be in a much better position to recognize the most efficient ways of assembling jigs and clamps. For these reasons the endeavor has been to ascertain only the true value of a welded joint as compared to that of a similar joint, riveted.

Before undertaking this investigation, the writer had been under the impression that in all past structurally welded members far more electrode material had been applied than was necessary to make the joint reliable, and one which would withstand safely the stress to which it was subjected. This impression was substantiated later, as the results of test showed.

The welded specimens were prepared at the General Electric Co., under the supervision of W. V. Lewis, structural supervisor, and welded by the departmental operator, W. Kutassy. The latter has been welding for the past ten months only, yet great dependence is placed on his efforts. I cite this fact, that it may be realized that actual welding operations were carried on to give an average rather than a maximum value.

Structural Members and Filling Material.—All structural members used in the tests were taken from stock, and no especial perparation of the surfaces to be welded was made other than the cleaning of those surfaces with a small wire brush. What scale and other surface impurities resisted the brush were allowed to remain. It is not meant to infer, however, that there should be no treatment of such surfaces; in fact, a small, portable sand blasting equipment is recommended, with which may be removed the tougher and more objectionable impurities.

The electrode or filling material used in joining the structural members was a standard, commercial, bare wire, the approximate analysis of which is as follows:

Carbon—low.
Manganese—high.
Sulphur—low.
Phosphorus—low.
Silicon—trace.

The tests may be divided into two groups:

1. Six preliminary tests, made to determine the approximate strengths of the different types of welds, in order that future joints might be designed with the strength of each fully developed.

2. Five tests following these, all being designed as nearly as possible, with the exception of the welded cross section which was varied with the individual test.

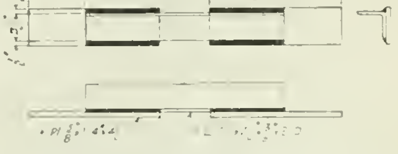

Fig. 1.

The first six preliminary tests may be further divided into two additional groups:

a. Joints composed of two plates and two angles, or of two plates and one angle.

b. Joints composed of four plates, as illustrated in the accompanying diagrams.

Six Tests to Determine Strength of Welds.—One angle of dimensions

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*From The Iron Age.

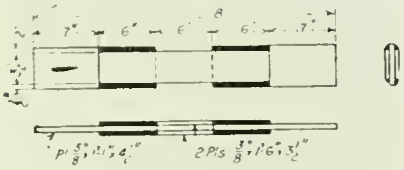

Fig. 2.

shown in Fig. 1 was lap-welded in shear to two flat plates, one plate at each end of the angle. All welding areas or cross sections are indicated by shaded portions. This specimen was gripped in the tensile machine and pulled apart to determine the ultimate strength either of the welds, the plates or the angle. In advance of the test the prediction was made that the weld would go before either the plates or the angle.

At 89,230 lb. the ultimate strength was reached. With the exception of a few small cracks, the welds were unharmed. Fracture occurred in the angle on a line approximately perpendicular to the line of stress and was seen to be one of shear; in addition, the specimen bent in two directions, as would have been supposed. This gave no numerical indication of the weld strength in shear, save that it was greater than that of the angle.

The specimen in Fig. 2 was made up of four plates (two end plates and two cover plates) welded, as before, in shear. Cover plates were used instead of one or two cover angles because it had been observed in the preceding test that there was induced too much bending in the specimen to give accurate results.

Under stress, the two end plates elongated and became deformed, until the ultimate strength of the two cover plates was reached, at 158,420 lb., when the two later broke in shear, perpendicular to the line of pull. Again it had been graphically demonstrated that the plates were too weak for the welds.

A third test was made up similar to the one in Fig. 1, except that in this instance two angles instead of one were used to connect the end plates. As had been foreseen, there occurred bending in the specimen to an amount sufficient to be readily noticeable and, quite probably, to effect the results obtained. In this case the strength of the plates and angles proved to be too much for the combined strengths of the welds, and the latter failed at 114,750 lbs. It is thought that a greater pull could have been withstood had there been no bending stress induced. It was desired to obtain the strength of each weld per lineal inch, but, because of the bending moment, this calculation was not made.

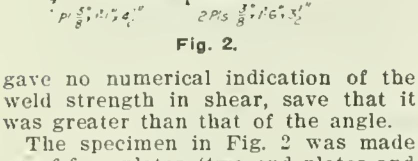

Fig. 3.

In the fourth test, Fig. 4, two cover plates were welded, in shear, to two end plates, as in the second test. By using four plates welded together in this manner, the bending moment was reduced to a minimum, and the results obtained represent true values of shear. The breaking strength was 149,500 lbs. Four of the eight welds broke almost simultaneously along a line parallel to the line of force and through their approximate centers. Calculations shown elsewhere give values per lineal inch of weld, and for shear per square inch of welded area on a plane parallel to the length of the weld.

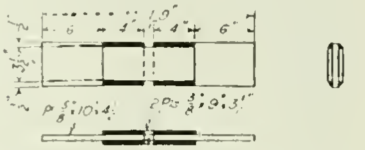

Fig. 4.

There was no designed difference between the fifth specimen, Fig. 5, and the one immediately preceding it, except that shorter lengths of weld were deposited in the latter instance. This specimen broke as did the other, to give an ultimate strength of 116,320 lb. The lineal strength, therefore, was equal to 9,685 lb. per running inch of weld; that in the fourth test was 9,340 lbs.

In this and in the last test the weld metal was deposited continuously in one solid bead; in test pieces of the second group, which are yet to be described, each welded volume was made up of two beads, a small one running along the line of intersection of the two welded surfaces, and a secone one over the first and filling in to the required volume. For cross section of bead thus described, refer to Fig. 5-A.

Fig. 6 shows that this specimen was designed to be the same as Fig. 5, save that the length of material deposited was as nearly as possible one-third that laid down in Fig. 5. It was thought that this weld would not be one-third as strong as in Fig. 5, because of weaknesses at the beginning and at the ending of the beads, which would be more pronounced in this, the smaller weld, thereby causing it to break sooner. This was found not to be the case.

On the contrary, the smaller weld was slightly more than one-third as strong as the longer weld, which, perhaps, was accounted for by the fact that in the shorter weld there was deposited a slightly greater proportionate amount of electrode material than in the other. Further tests might prove that weld strength varies directly with the length of the weld. The ultimate strength of this specimen was 45,570 lb. Fractures occurred in the welds, parallel to the direction of stress.

It will have been noticed that, in the tests above described, little was given in regard to the computations for strength of welds. The main reason for making the tests was to determine an approximate value for strength in shear of each type of weld so that, in designing further specimens, there would not be deposited so large an amount of electrode metal that the plates, and not the welds, would fracture.

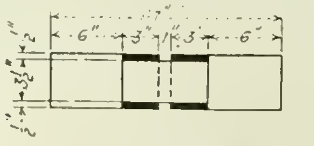

Fig. 5.

The Last Five Tests.—These five tests are grouped together because of the longitudinal dimensions common to all. In Fig. 7 the dimensions shown are constant; those left blank vary with the type of specimen and may be found further along. Welding is indicated by the shaded portions.

In each of the five groups of tests about to be described there were broken four specimens, all four being designed alike, making a total of twenty individual fractures. From the data obtained calculations have been made and conclusions drawn. The twenty test pieces were welded under the following conditions, as nearly as possible alike:

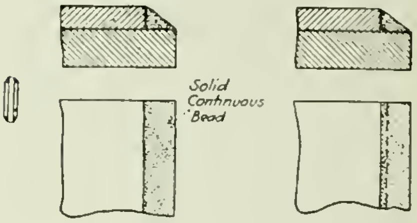

Fig. 6.

Welded length, each specimen: Eight 3-in. welds; total, 2 ft.
Voltage: Open circuit, 60; arc, 20.
Steel: Structural, taken from stock.
Electrode: Standard make, of composition given above, diameter, 5/32 in.
Size rivets: ⅞ in. used in calculations of relative strength of joint, welded or riveted.

All test pieces were of the same longitudinal dimensions but, to secure the desired cross sectional areas of beads, the thicknesses and widths of the various plates employed necessarily varied, information for which is given in Table I.

Throughout the course of the tests a careful measurement was taken of the amount of electrode material deposited and of the time required to weld each specimen. A glance at Table II will show that, as one would have expected, the amount of filling material increased as the cross sectional area of the bead was increased. This was not the case when the length of time taken to weld was observed; time did not vary directly, or even approximately, with the area of the bead.

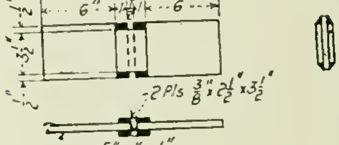

Fig. 7.

To be of commercial value, the fairly definitely known percentage. strength of any one of a number of welded joints may not vary from their mean value by more than a small and Our experiments demonstrate that, in this type of joint, the variations in strength are small and compare favor-

TABLE I—SPECIFICATIONS.
(All dimensions in inches.)

Test No.	Bead "A"	Bead "B"	Plates No.	Plates Size
8	½	½	2	¾x9 x4
			2	½x6½x3
6	⅜	½	2	⅝x9 x4½
			2	⅜x6½x3½
9	⅜	⅜	2	⅝x9 x4¼
			2	⅜x6½x3½
10	¼	⅜	2	⅝x9 x4¼
			2	¼x6½x3½
11	¼	¼	2	⅝x9 x4
			2	¼x6½x3½

TABLE II—WELDING OPERATIONS.

Test No.	Arc volts.	Electrode: Size, In.	Electrode: Amount (Each spec.) Lb.	Amperes.	Time: Total, ft.	Time: Rate (Lineal in. per min.)
8	20	5/32	1.39	175	33.00	0.73
6	20	5/32	0.966	175	19.87	1.22
9	20	5/32	0.77	150	22.75	1.06
10	20	5/32	0.551	150	14.25	1.686
11	20	5/32	0.328	150	9.00	2.67

ably with joints riveted in the usual way. The widest deviations from the mean occurred in test No. 8, where the plates were heaviest and where, in consequence, the beads were of the greatest cross sectional area. In four of the five groups of tests no one variation exceeded 2.2 per cent of the mean value; in the fifth (Test No. 8), the largest variation was 5.79 per cent. From this we conclude that the welded union is not the cheangeable quantity which some might expect it to be, but is fully as dependable and as strong as any other common type of joint. Table III lists the variations as they were determined from tests made.

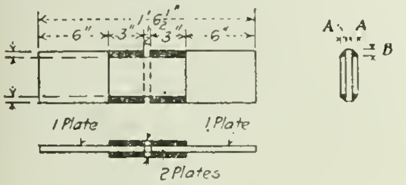

Fig. 8.

Comparison of Welds with Computed Riveted Strengths.—It is interesting to compute the riveted strengths of the joints tested for weld strength and to compare these figures with those obtained from the breaking tests. It will be observed that these particular types of unions could not be riveted to give a strength equal to that of the same joints, welded. Only one rivet can be used in each section, and it cannot exceed a diameter of ⅞ in.

Table IV makes the following assumptions: Ultimate tensile strength of mild steel ordinarily used in structural work, 60,000 lb. sq. in.; rivet strengths, in single shear, 45,000 lb. per sq. in.; bearing, 90,000 lb. per sq. in.

Our welds gave shearing values which varied, in intensity inversely as the cross sectional area of the bead. In comparing the calculated shearing value of structural steel with the observed values of the welds, a unit shearing value of 45,000 lb. per sq. in. was assumed as the ultimate shearing strength of the steel. Table V gives the shear for the five groups: it varies from 33,650 lb. per sq. in. in the weld of largest sections to 42,900 lb. per sq. in. in the smallest, indicating that, in some respects, a small weld is more economical of strength than a large weld. Based on the value of 45,000 lb. given above, the calculated efficiency of the smallest—and of the best—weld, in shear, is 95.4 per cent.

TABLE III—STRENGTH VARIATIONS.

Test No.	Ultimate strength of weld (average, lb.)	Largest percentage variation from mean.
8	142,500	—5.79
6	131,110	—1.22
9	120,000	—2.20
10	96,400	—1.73
11	89,650	1.88

Below is given an equation to show the length of bead required to develop the full strength of the plates used in the joint:

$$L = \frac{AT}{S} \text{ in which,}$$

A is cross sectional area of plate, or plates, in sq. in.; T is ultimate tensile strength of plates in lb. per sq. in.; S is strength per lineal inch of bead, which varies with the sizes of bead used, and which may be taken from Table VI; L is total length of bead required to develop full strength of plates.

Results are given in Table VI of computations which determine the labor cost of depositing a length of bead which shall have a resisting strength of 1,000 lb. To simplify computation in this illustration, the welder's wage is assumed as 60 ct. per hour. It will be seen that these costs vary in no regular manner, and that the weld of smallest section is the most economical of the five shown.

TABLE V.—SHEAR.

Test No.	Calculated: Area, Sq. in.	Calculated: Strength, Lb.	Ultimate weld strength, Lb.	Per cent efficiency.	Actual weld (Lb. per sq. in.)
8	4.23	190,500	142,500	74.8	33,650
6	3.60	162,000	131,110	80.9	36,400
9	3.18	143,200	120,000	83.8	37,730
10	2.50	112,400	96,400	85.8	38,600
11	2.09	94,000	89,650	95.4	42,900

TABLE VI.—COST DATA.

Test No.	Bead size, In.	Lb. per lineal in.	Total time, Min.	Total cost, c.	Cost per 1,000 lb., c.
8	½x½	11,870	33.00	33.00	2.78
6	½x⅜	10,925	19.87	19.87	1.82
9	⅜x⅜	10,000	22.75	22.75	2.28
10	⅜x¼	8,030	14.25	14.25	1.77
11	¼x¼	7,470	9.00	9.00	1.21

Knowing that a large number of tests had been made to determine the strength of butt and of lap welds, within each of which is found tension, compression, or shear, or a combination of two or more of these forces, the writer resolved to assemble test specimens which would give as nearly as practicable a pure shear. The foregoing experiments have been performed to this end. Our test data are limited and is not capable of exterpolation, but we believe that what we have available is indicative of the possibilities of structural welding in a rational and scientific manner. The writer is indebted to Prof. Frank P. McKibben, Union College, for his interest in the work, and for his many suggestions, and to B. C. Tracey, General Electric Co., for his assistance in furthering the progress of the experiments and in the perparation of this manuscript.

TABLE IV.—COMPARATIVE STRENGTH.

Test No.	Calculated for Plates. Gross, Lb.	Calculated for Plates. Net, Lb.	Rivets: Per cent effic.	Rivets: Double shear (Lb. per sq. in.)	Rivets: Bearing (Lb. per sq. in.)	Ultimate weld strength, Lb.
8	180,000	135,000	75.0	54,000	59,100	142,500
	180,000	120,000	66.7		78,800	
6	169,000	131,500	77.8	51,000	49,250	131,110
	157,700	112,500	71.3		59,100	
9	159,500	122,200	16.6	54,000	49,250	120,000
	157,700	112,500	71.3		59,100	
10	159,500	122,200	76.5	51,000	49,250	96,400
	105,000	75,000	71.4		39,400	
11	150,000	112,500	75.0	54,000	49,250	89,650
	105,000	75,000	71.4		39,400	

Marine Destroyers of Harbor Works

What They Are and How They Work Described in Paper Presented Sept. 15 at Convention of American Association of Port Authorities

By DR. HERMAN VON SCHRENK.
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Marine borers have for centuries been the bane of the engineer and shipbuilder interested in the construction and maintenance of wooden piers and boats the world over. The term "marine borer" is applied to a group of low animals living in the seas, which either bore holes into the submerged portions of wood in salt or brackish water, or which chew off the outside of the wood, in either case rapidly destroying its structural value.

Marine borers have been known since the time of Caesar, and attention is called to the fact that they were probably well known long before that. Early Greek and Roman writers frequently refer to these borers and give simple remedies for the protection of boats. In more recent times the activities of some of the marine borers, particularly the Holland shipworm, occurred in cycles with unusual severity, notably in the following periods: 1730-32, 1770, 1827, 1858-59, when it attacked the dykes of Holland during periods of reduced rainfall.

Two Groups of Destructive Marine Borers.—Without going into too much detail it may be stated that there are two groups of destructive marine borers belonging respectively to the families Mollusca and Crustacea. The oysters and clams are typical representatives of the Mollusca; lobsters crabs, etc., are typical representatives of the Crustacea. The oyster and clam group is represented by two forms; Teredo and Xylotria. Both of these bore into the wood, forming long tunnells, separated only by very thin partitions. The Crustacean group, represented by the genera Limnoria, Sphaeroma and others, chew the wood, forming more or less shallow burrows, which eventually results in the hour-glass form and the ultimate total cutting in two of the pile.

How the Teredo Bores.—Referring briefly to the Molluscan forms, the Teredo and Xylotria: The adult form are long, wormlike creatures, with soft bodies, lying in the burrows which they have excavated, with their heads toward the interior of the wood and the tail end at the outside of the wood. The body of the animal secretes lime which completely coats the walls of the tunnel in which they live. The actual boring is done by means of two minute shells which form part of the head. These correspond to the two shells of the oyster and clam. The edges of the shells are provided with minute filelike teeth which are rasped back and forth, activated by a most ingenious mechanism. They may be pictured as functioning very much like the clam shell dipper. At the tail end the animal has two sets of organs, the siphons and palates. The siphons are two rubes which project out into the water between the palates. Activated by fine hairs in the body cavity a current of water passes in through one of the siphons, and after circulating around in the body is forced out through the other. These siphons are evident in the clam and the outgoing water current is probably familiar to most of you who have witnessed clams squirting small geysers of water up from the sand on any sea beach. The palates are two-feather shaped, segmented structures attached to the side of the body by stacks. Each palate is convex on the outward face and concave on the inner face, and the two when brought together form a cone with the point outward. The palates are protective devices, for when disturbed the animal draws the siphons back into the hole, brings the two palates together, and very effectively seals the hole against intruders.

The food of these borers so far as known consists chiefly of what is known as plankton by zoologists, meaning thereby a large number of marine organisms, both plant and animal, most of them miscroscopic in size. Dr. C. A. Kofoid, Professor of Zoology, University of California, in speaking of this plankton has the following to say:

"The ocean in common with lakes and rivers, produces each year crops, or rather a continual succession of crops, of a microscopical food supply known as plankton or ocean meadows, whose tonnage per acre is comparable in weight and chemical composition to the forage crops of wild or cultivated land. The marine borers feed on this exclusively, appropriating it as it passes their door. They never go foraging except in the case of the free-swimming larvae. This food supply is not equal in abundance at all times or in all places. In the ocean meadows it runs a seasonal course not unlike that of the land. Other things being equal the spring and early summer and the autumn are periods of most abundant food and therefore the periods of reproduction and growth of the borers. There is, however, a sufficient amount of such food present at all seasons and in most localities, to provide for the maintenance and for some growth of the borers. Differences in the effectiveness of their invasion and the consequent industrial menace in different localities, and their varying rate of growth in different seasons are directly attributable inside the zone of varying salinity to varyings of the food factor." In other words, the Teredo and Xylotria forms, and this is also true of the other types of marine borers, so far as known do not appear to live on the wood but simply use it as a shelter.

The Development of the Teredo.—Teredos and Xylotria develop from eggs. In the case of the teredo these are hatched within the body of the female. The number of these eggs laid is enormous. According to the Dutch naturalist, Sellius, the eggs in the body of a single teredo are estimated at 1,874,000, and this number may even be exceeded. The young larvae are free-swimming and attack any available wood almost at once. The total number in a teredo infested locality of these larvae may be imagined when it is remembered that there may be as many as 80,000 females in a pile, each producing over a million young ones. The minute larvae are carried about by tidal action and in view of their numbers it is easy to see why rapid infection is more than probable when once they become established. A brief picture of their activities may be of interest. Imagine thousands of long, wormlike creatures all the way from 6 to 12 in. long, and varying in thickness from the diameter of a led pencil to that of your thumb, enclosed in a wooden pile the palates and siphons sticking out through the small holes on the outside of the pile; at the other end two small shells are rasping away at the wood constantly, increasing the length of the burrow. The fine sawdust which they rasp off passes through the body and streams out of the excurrent siphon in such qauntities that together with the siphons and palates a pile in which they are working looks as if covered with moss. Add to this picture 50,000 to 100,000 of these creatures in one pile and you will readily understand how it is possible that they ate off a Douglas fir pile almost 2 ft. in diameter in less than six months.

Effect of Salinity of Water on Borers.—The amount of salt contained in waters has a determining influence on the existence of these borers. Quoting from Dr. Kofoid: "The Molluscan borers are particularly susceptible to salinity because they continuously bathe their bodies in a stream of water brought in through the incurrent siphon. The lowest levels of salinity at which Teredo navalis will survive in piling appear to lie between 7.5 and 10 parts per thousand. The levels at which the larval stages will attack piling probably lie somewhere above this, perhaps between 10 and 15 parts per thousand. The limits of salinity within which the different species of Teredo thrive vary greatly. The borer Nausitoria Dunlopi lives in the River Como in India in fresh water. The Teredo navalis, on the other hnad, is a species adapted to live in brackish water, while the shipworm, Teredo Megotara, lives in timbers on the high seas. Xylotrya Setacae on our coasts lives in maximum salinities and has not been found to thrive in waters below twenty parts per thousand. From the foregoing it will appear that the different marine borers have different degrees of tolerance for waters with high and low salinities, and it seems probable that each will thrive best under salinities of a rather different degree. The marine borers as a whole have such a cosmopolitan distribution from the equator almost to the Artic Circle and such a wide range of adaptedness that the temperature changes in adjacent localities have very little influence over their distribution. They do, however, set limits to the occurence of particular species. In common with other animals the borers cannot live without oxygen. Waters in which the oxygen quantity is too low to support life will, of course, be free from these organisims. Temporary sewage pollution can be tided over by them provided sufficient oxygenated water is subsequently supplied. By closing the palates they can rest for a certain period but not indefinitely. High sewage pollution, therefore, may frequently result in making water unfit for their life processes and thereby render a harbor immune; however, recent developments in San Francisco indicate that some species of borers thrive in highly polluted waters. The factors of shelter, water currents, seasonal variations, etc., are all obvious and require little more than a reference."

The species of Teredo and Xylotria are known all over the world. So far as we now know most of them work with greater activity in the warmer waters than they do in the colder waters, but recent activities as far north as the North Cape in Europe indicate that they can be sufficiently destructive even in cold waters to cause anxiety.

There has been much recent discussion as to the specific identity of the various forms of Teredo and Xylotria. Except to point out that where structurally the animals in one part of the world closely resemble known forms in another part of the world, mere specific differences are of less interest to the engineer than the fact that these animals work under much the same conditions and in the same way.

Limnoria or Boring Gribble.—I have dwelt somewhat lengthily on the teredo group but believe reference should be made to some of the other borers. The Limnoria, known as the gribble or the boring gribble, is found on all our coasts. It looks something like a grain of rice but is easily recognizable because it has a body consisting of fourteen segments, with stout legs, some of them having claws like young lobsters. It chews the wood and makes small cavaties or depressions about 1-16 in. in diameter and about ½ in. deep. It is the creature that is responsible for the hour-glass appearance of piles in many of our harbors. It has been found on all North American coasts, in practically the same localities as the Holland shipworm in Europe.

Two other borers are Sphaeroma or Chelura, the former looking like a sowbug or pillbug. Now and then a clamlike creature bores into piles and ships called nartesia, shown on the next slide. It is of lesser importance because it never goes very far into the wood but in the case of ships, it may bore holes sufficiently large to puncture the bottom, as recently occurred in a creosoted barge in the Harbor of Santiago, Cuba.

Distribution of Marine Borers.—In referring to the distribution of these creatures the engineer is naturally interested in finding out where they have been found, and what is of equal interest, whether there is any liklihood of their appearing in places where they have hitherto not been known. Unfortunately we have only very meager information as to the actual distribution of these various borers on the various sea coasts of the world. Attention is called to a series of very interesting maps recently prepared by a joint committee of the Danish, Swedish and Norwegian Engineering Societies showing the activ ity of the Teredo and Limnoria on the northern coasts of Europe during the last year. We need such maps for North America and the data necessary for such distributional maps are now being secured.

Investigations Now Underway.—One reason why we are so very much interested in these marine destroyers of our harbor works is because of the comparatively recent appearance in San Francisco of what zoologists agree is the typical Holland shipworm. San Francisco has been singularly free from marine borer attack, possibly due to the absence of this organism and also to the low salinity of the water. In 1919 they appeared in countless millions and destroyed docks and wharves as indicated in some of the following slides. Those of you who are interested are referred to the very excellent reports* which have been published by the San Francisco Bay Marine Piling Committee with full details and descriptions of preventive measures so far undertaken. The excellent work done by the San Francisco Committee clearly indicated the necessity for a very much wider investigation than was possible in California and an appeal was made to the National Research Council, as a result of which a committee was appointed to correlate the investigative activities already existing and to initiate new ones. These activities extend to governmental and scientific institutions in the United States and Canada, and I am glad to report progress to you this evening. The committee has planned investigations dealing with all types of marine construction, including wood, concrete, metal and stone. They are devoting their principal attention at the present time to the placing of test pieces of wood in the harbors of North America and South America for the purpose of determining what borers are present and where. These test pieces consist of 24 small blocks, two of which are removed each month. Immediately upon removal these blocks are sent to recognized zoologists who examine them and tabulate the organisms found. The careful prosecution of this work should in a comparatively short time give us an idea of where the borers are now working and what kinds of borers are at work. Another set of investigations deals with getting accurate data as to temperatures, salinities, hydrogen-ion concentration of the waters of the more important harbors.

Many of us have thought for many years that freedom from borer attack in numerous harbors has been due to heavy sewage pollution which made the living conditions impossible for the borers. This undoubtedly has a bearing but we are not quite so certain that this is always true, because the work of the last year has indicated that the true, Holland shipworm can live in very highly sewage infested waters. A further line of investigation planned and actually in operation at the present time deals with the accumulation of data as to protective measures, both as to unprotected structures in existence, and for new work. The committee has also formulated investigations dealing with obscure points in the life history of these creatures with particular reference to the kind of chemical relation which may exist between various borers and various compounds.

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*Proceedings American Wood Pres. Association, 17th annual meeting, 1921, 14189-339.

Proceedings American Wood Pres. Association, 18th annual meeting, 1922 (in press). Issued as separate.

Index Numbers of Wholesale Prices January, 1913, to September, 1922

The accompanying tabulation shows the revised index numbers of wholesale prices by groups of commodities as computed by the U. S. Bureau of Labor Statistics.

The group of miscellaneous commodities includes such important articles as leather, cottonseed meal, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, starch, tobacco, Manila hemp, sisal and wood pulp. The commodities, composing the other groups, are as indicated by the titles.

The new index numbers and the following explanations, are from Bureau of Labor Statistics, Form 1531:

The weighting of the prices used in constructing the index numbers for the different groups of commodities by the new 1919 census figures of production, instead of the 1909 data used in preceding reports, conforms to the plan contemplated by the Bureau at the inception of its weighted index number system in 1914 of revising the weighting factors every ten years as new census information should become available. All computations have been carried back to 1913 in order to insure comparability of the figures and also to provide a prewar standard for measuring wholesale price changes.

The following table gives the revised index numbers for the several commodity groups from January, 1913, to the latest month for which complete information is available. For comparison with the new series, the old general index of all commodities is shown in the last column of the table. Publication of the old series was suspended with the April, 1922, figures.

REVISED INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES AND BY MONTHS, 1913 TO 1922 (1913 EQUALS 100).

	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	All commodities.	
										New index.	Old index.
1913	100	100	100	100	100	100	100	100	100	100	100
January	98	99	99	100	107	101	100	100	106	100	100
April	99	98	100	98	104	103	101	100	100	100	98
July	99	101	100	99	98	99	100	100	100	100	100
October	103	102	101	102	97	98	100	101	98	101	101
1914	103	102	98	93	85	92	101	100	95	98	100
January	103	101	99	99	88	93	98	100	94	98	100
April	102	95	99	98	88	93	97	100	98	98	98
July	103	99	99	91	83	92	95	100	93	97	100
October	101	106	96	88	83	90	108	100	92	97	99
1915	104	105	98	88	99	94	134	100	95	101	101
January	104	106	94	87	82	88	108	99	99	98	99
February	105	108	95	86	86	89	116	99	93	99	101
March	104	106	96	84	88	90	118	99	93	99	99
April	104	105	96	82	90	90	118	99	93	99	100
May	105	105	96	82	96	93	116	100	93	100	101
June	101	102	96	81	102	93	123	100	93	99	99
July	101	104	96	81	106	94	130	100	94	100	101
August	103	102	97	85	103	93	136	100	93	100	100
September	101	99	99	91	104	94	143	100	92	100	99
October	106	102	101	94	105	98	151	100	93	102	101
November	104	106	105	98	110	101	165	100	95	104	103
December	105	108	107	103	122	104	179	101	100	108	106
1916	123	121	127	126	162	120	181	106	121	127	124
January	110	109	110	113	133	110	84	103	110	113	110
February	110	110	114	115	142	113	204	103	105	115	112
March	111	112	117	119	156	118	206	104	108	119	114
April	113	114	118	120	164	120	200	104	110	121	117
May	115	115	120	120	168	121	193	105	114	122	118
June	114	115	122	122	164	120	191	105	120	123	119
July	117	117	125	121	158	120	175	107	120	123	119
August	125	122	128	116	157	120	157	107	121	126	123
September	131	126	130	120	160	121	158	107	124	130	128
October	136	134	137	128	164	124	164	109	132	136	134
November	147	141	147	155	174	126	167	111	139	146	144
December	146	137	154	163	190	132	172	111	147	149	146
1917	190	167	175	169	231	157	202	125	148	177	176
January	152	140	158	171	198	138	173	118	149	153	151
February	157	145	157	178	201	140	173	119	150	157	156
March	166	148	158	174	218	144	181	120	151	162	161
April	184	164	164	164	230	155	186	121	153	173	172
May	196	175	167	178	240	159	194	121	151	183	182
June	195	171	174	183	267	169	195	123	153	185	185
July	196	169	181	176	292	168	205	129	153	188	186
August	202	175	186	167	282	167	211	129	150	180	185
September	202	176	185	160	260	167	223	130	147	187	183
October	207	180	185	153	207	156	231	130	142	183	181
November	212	181	191	161	133	156	223	131	140	183	183
December	207	181	195	163	183	158	228	133	140	182	182
1918	218	188	228	170	187	172	215	153	156	194	196
January	211	182	201	164	183	161	223	137	145	184	185
February	211	183	205	164	184	161	227	138	145	186	186
March	211	179	211	165	184	164	229	140	147	187	187
April	212	181	220	166	184	169	228	141	152	190	190
May	209	180	226	169	185	170	222	146	155	190	190
June	210	180	233	169	184	172	205	152	160	191	192
July	217	185	228	175	189	177	209	159	159	196	198
Aug.	227	189	239	175	190	179	212	161	160	200	202
September	234	195	215	176	190	179	210	163	161	201	207
October	225	198	245	176	192	177	211	164	163	202	204
November	225	204	241	179	191	177	209	164	164	203	206
December	227	206	233	179	187	177	194	163	163	202	206

	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	All commodities.	
										New index.	Old index.
1919	231	207	253	181	162	201	169	184	175	206	212
January	221	203	220	178	175	176	181	167	166	199	203
February	216	194	210	178	170	173	169	165	163	193	197
March	224	199	203	178	163	171	162	164	161	196	201
April	230	205	205	177	153	169	160	167	160	199	203
May	234	210	216	178	153	173	161	168	161	202	207
June	226	204	243	180	154	189	162	180	167	203	207
July	241	210	262	181	160	209	167	183	177	212	218
Aug.	242	214	276	184	162	226	170	188	187	216	226
September	225	205	283	188	161	229	170	190	189	210	220
October	227	205	291	189	162	229	173	194	187	211	223
November	237	210	304	188	164	232	176	217	189	217	230
December	242	220	317	189	168	248	182	222	189	223	238
1920	218	220	295	241	192	264	200	254	196	226	243
January	247	231	339	194	175	274	189	239	194	233	248
February	237	222	346	199	190	293	195	242	197	232	249
March	237	220	344	208	197	297	205	242	200	234	253
April	243	238	336	231	203	300	210	242	206	245	265
May	241	218	328	239	202	293	213	247	208	247	272
June	237	243	314	250	200	275	212	248	205	243	269
July	233	238	300	269	202	269	212	275	203	241	262
August	218	221	286	269	202	265	209	274	199	231	250
September	210	215	266	281	200	255	205	273	195	226	242
October	187	201	245	280	191	240	198	271	188	211	225
November	173	190	226	264	176	215	181	260	179	196	207
December	152	170	215	254	160	204	164	242	166	179	189
1921	124	144	180	199	129	165	136	195	128	147	153
January	143	162	196	247	153	192	153	217	154	170	177
February	133	151	188	225	147	180	149	217	147	160	167
March	127	151	183	212	140	173	143	216	139	155	162
April	117	144	176	205	138	167	135	216	130	148	154
May	118	139	173	200	138	165	134	209	126	145	151
June	114	137	172	191	133	163	133	196	125	142	118
July	119	141	172	186	124	160	129	180	123	141	148
August	123	146	171	184	117	156	129	179	119	142	152
September	124	142	178	181	116	156	131	179	118	141	152
October	124	140	180	189	116	159	131	180	118	142	150
November	121	139	180	197	111	163	129	178	119	141	149
December	120	136	180	199	113	158	127	178	121	140	149
1922—											
January	122	131	176	195	112	157	124	178	117	138	148
February	131	135	174	191	110	156	123	177	117	141	151
March	130	137	172	191	109	155	125	175	117	142	152
April	129	137	171	194	113	156	124	175	116	143	152
May	132	138	175	216	119	160	122	176	116	148	...
June	131	140	179	225	120	167	122	176	114	150	...
July	135	142	180	254	121	170	121	173	114	155	...
August	131	138	181	271	126	172	122	173	115	155	...
September	133	138	183	244	134	180	124	173	116	153	...

Fitting Timber Crib to Rough Rock Foundation

By M. E. CHAMBERLIN,

Registered Civil Engineer.

In replacing a 180-ft. Howe timber truss with two 90-ft. plate-girder spans a timber crib 12x28 ft. was used, when filled, as a base for the new pier. The placing of this crib required the determination of surface elevations of the ledge rock forming the river bottom. Soundings made from a boat proved that, by reason of the extreme unevenness of the ledge rock, a large number of closely spaced soundings were necessary.

To determine the exact location of each of these soundings some method other than the use of the boat had to be devised. A horizontally flat frame the exact size of the proposed crib was constructed of boards and suspended from the old truss by 2x4-in. hangers and sway braces; the bottom cord of the truss being about 20 ft. above the water and the frame barely clearing the surface. In the absence of the old truss the frame could have been held in place as a float by guys secured on the river bank.

Soundings were made with a stiff steel rod 16 ft. long, the water depths varying from 8 to 12 ft. The approximate deflection of the submerged end of the rod by the velocity of the river flow, when the exposed portion was vertical, was first determined by test. Soundings were then made at maximum distances of 12 in. along both the outer and inner edges of the frame. These two parallel rows of soundings were 1 ft. apart, this being the thickness of the crib walls.

The comparative elevation of the ledge rock at each sounding was platted on a diagram drawn to scale. Intermediate soundings which indicated a uniform slope were noted in the field but were not platted. The bridge carpenters then cut the 12x12-in. fir crib timbers to conform with this diagram. After being sunk in position, by the use of rock filled bins, the top of the crib lacked only ½ in. of being level.

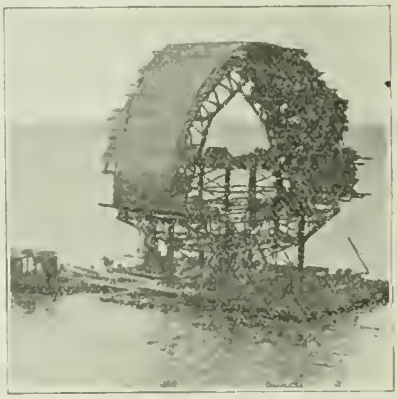
To prevent the flowing river water from washing newly placed concrete out of any spaces between the crib timbers and the ledge rock, boards to which were fastened large, loose rolls of burlap were placed around the bottom of the crib. The crib was then filled with concrete and boulders. On removing this burlap it was found that the concrete had come in contact with it at only a few places; another indication of a good fit between crib and ledge rock.

A temporary pier was constructed on this crib, using 12x12 in. and 8x16 in. fir timbers. The total average height of crib and pier was 26 ft., and included 16 tiers of horizontal joints. Although these joints were fairly well fitted the bridge seat settled nearly 3 in. under the combined load of one-half of two 90-ft. deck-girder spans together with the track carrying the work train.

1923 Convention of Associated General Contractors.—The annual convention of the Associated General Contractors of America will be held Jan. 30 to Feb. 2 at Los Angeles, Calif.

Bridge Centers Handled by Traveler Mounted on Barge

A steel traveler, mounted on a barge and carrying steel centers, was used by the James McGraw Co., contractors, in the construction of a bridge across the Susquehanna river at Harrisburg, Pa., for the Philadelphia & Reading Ry. The following account of the feature is taken from Successful Methods. The new structure is part of the railway's bridge renewal work now in progress at various points. The Harrisburg bridge consists of 46 concrete arches, each span being 66 ft. In order to maintain traffic on the existing steel structure, a part of the new bridge, 13 ft. 9 in. in width is being built first. After this portion of the work is completed, the track will be shifted over from the old structure to the concrete arches and the remainder of the bridge concreted. This operation, therefore, will require a total of 92 setups of the arch ribs, 2 setups for each span. On account of this fact, and also that the bridge is over the water for practically its entire length, it was decided that the most economical and efficient method of handling these centers would be on some type of traveler mounted on a barge. Due to a considerable grade, there is a difference in elevation of the spring line of approximately 24 ft. from one end of the bridge to the other. It, therefore, was necessary to design a traveler having one fixed part and two sliding parts. This feature of the traveler allows it to pass under the centers at the low end and still be able to reach the centers at the high end.



One of the Centers in Midstream Below Bridge During Shifting Operation.

For placing the centers, the traveler is towed underneath and the sliding frames are raised up until they engage the heel of the steel ribs. The centers are raised and lowered by means of worm-geared safety winches. This type of winch was adopted in order to avoid any possible accident due to the dogs being accidentally displaced or the possibility of the load getting away from the man operating the winches. When it is desired to move the centers, they are pulled in horizontally by means of ratchets and lowered by means of the worm safety winches and are towed to the next span, when the operation is repeated.

For handling the concrete a single narrow-gage track, carried on cantilevered supports from the upper part of the present structure, is supplied by a 1-yd. mixer plant with tower at each end of the bridge. A derrick boat in the river handles the forms.

Roads and Streets Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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How to Secure Increased Salaries for City Engineers

As shown in our October issue the salaries of city engineers in cities of 4,000 to 30,000 people average about $210 a month, and in cities of 30,000 to 100,000 the average is about $304 a month. Considering the duties and responsibilities of the city engineer, any such salaries are ridiculously low. The problem before civil engineers—not merely before city engineers—is how to convince city councils that city engineers should be paid 50 to several hundred per cent more than they are now receiving.

If the city engineer goes before a city council unaided, his request for an adequate salary is apt to receive scant attention. He controls few votes, and, as a rule, he is not an aggressive fighter for his own economic rights; so the average councilman talks approvingly of, but refrains from, voting on an adequate increase in the city engineer's salary.

Even the argument of increased cost of living, effective as it often is, seems usually to be ineffective in persuading a city council to raise engineering salaries the needed 65 per cent above the pre-war level. Councilmen are undoubtedly influenced by the cost of living indexes published by the U. S. Bureau of Labor, showing how much (65 per cent) the cost of living has increased in the country as a whole. But something more is obviously needed to persuade them to increase engineering salaries even to the extent that living expenses have increased.

We have frequently suggested that we believe it to be the duty of engineering societies, both local and national, to educate chambers of commerce and city councils to at least partial recognition of the value of engineering services. We have pointed out that such an educational process is apt to fail in its purpose if reliance is placed entirely on printed and written words. Spoken words are far more persuasive than printed words, when they are uttered by men who know how to speak and who know whereof they speak. An oral address can neither be pigeon-holed nor waste-basketed. It has, moreover, the emotional quality that is needed to create immediate action on the part of the listener.

In every engineering society, even the smallest, there are at least a few effective public speakers. They are the type to present to the public and its representatives the facts that indicate the value of good engineering services. The chamber of commerce and the Rotary Club in every city should be addressed periodically by effective speakers on the subject of engineering services and their value. These addresses should be made by engineers selected by engineering societies. At first the addresses need not necessarily point out the inadequacy of the salaries of city engineers. But eventually statistics should be presented showing the percentage relationship between the city engineer's salary and the annual expenditures made under his direction. Contrasts should be made with the percentage payments for engineering and architectural services where corporations and individuals employ designers of structures. It should be made clear that the capitalized cost of one design may vastly exceed that of another design, and that a recognition of this fact has led private employers to pay what seems to be very high salaries or fees to engineers who have demonstrated their economic efficiency.

It should be shown that even a mediocre engineer under the spur of ambition to earn a higher income will often surpass a more talented engineer who lacks such an incentive. In short, the managerial "law of payment proportional to economic performance" should be elucidated, and its application to the payment of city engineers made clear.

Very few business men know much about the work that a city engineer performs, and therefore have no conception of the opportunities for conservation or for waste that exist in the city engineer's office. If they had even a partial appreciation of the amount of money at stake, being taxpayers they would certainly make their desires felt in the matter of securing the best of engineering services for the city. And, being business men, they would know that the best of services in any line are rarely secured without liberal payment for them.

The campaign for adequate pay for

city engineers and their assistants should be started among the business men and other taxpayers. It might even be financed by a few public spirited men of means. But even were the entire expense of it borne by the local engineering society, it would, we believe, ultimately be returned indirectly many fold; for when even one engineer in a community secures a compensation that is approximately adequate, every other engineer is aided in his efforts to secure an adequate income. By concentrating all effort in behalf of one engineer who is in the public eye, it should be feasible for organized engineers to secure for that one—the city engineer, for example—a salary commensurate with the value of his services.

Sixteen years ago the editor secured $1,000 a month for his services as Chief Engineer of the Railroad Commission of the State of Washington. This salary was double that received by the Governor of the State. It was regarded as being so exorbitant by the State Auditor that he refused to pay it until forced to do so by the Supreme Court. Naturally the daily papers in Washington gave considerable publicity to the fact that a state engineer was receiving $12,000 a year. Probably most taxpayers had previously regarded $5 a day as pretty liberal pay for any engineer.

The editor was told by many engineers in Washington that the mere fact that one publicly employed engineer had received $1,000 a month would make it easier for other engineers to secure better compensation.

Certainly if the city engineers of most cities were paid as large salaries as the importance of their position warrants, other civil engineers would find it far less difficult to get better incomes.

Reconstruction and Repair of Worn Brick Pavements

More than 20 years ago the editor, while engaged in highway work, was so impressed by the fact that paving brick were frequently worn to a thickness of only 1½ ins. without breaking that he published an article suggesting that brick should be laid flatwise instead of edgewise wherever the traffic was not likely to cause rapid abrasion. This suggestion was subsequently repeated in his "Handbook of Cost Data," and was adopted by several city engineers, thus leading eventually to a very general flatwise use of paving brick and block.

Most of the abrasion of existing brick pavements dates back to the days of horse-drawn, iron-tired vehicles. Hence badly worn brick pavements are relatively old. Their very age is apt to lead to their being regarded as being beyond repair. But before throwing away thousands of dollars' worth of material the city engineer should consider carefully how it may be salvaged.

A badly worn brick pavement may usually be salvaged either by relaying the brick or by surfacing it with sheet asphalt. If the relaying plan is adopted the brick may be laid either bottomside up or sidewise. In either case usually not more than 10 per cent of new brick need be purchased.

In some cases it may be wise to use the old brick on a street where the traffic is lighter than on the street where it has been giving service.

In surfacing a worn brick pavement with asphalt, Harlan H. Edwards, City Engineer of Danville, Ill., recommends a 1-in. binder course and a 2-in. wearing coat. He has recently resurfaced 30-year-old brick pavements in this manner, some of which were two-course brick laid on sand, some one-course brick on gravel. The brick pavement was swept clean, and joints dug out to a depth of ½ in. Then a coat of asphaltic cement was sprinkled upon the brick, followed by the 1-in. binder course of asphaltic cement, sand and gravel. The 2-in. wearing course was of asphalt, fine sand and stone dust.

Since this resurfacing raises the grade 3 ins. certain other expenses are incurred. Either the curbs must be relaid or provision must be made for the more frequent discharge of storm water. Also pavements at intersecting streets and alleys must be relaid for at least 10 ft. back of the intersections. In one instance, this additional work added 50 per cent to the cost of the 3-in. asphalt, thus running the cost up to a point where it would have been cheaper to have laid an entirely new pavement.

Where street car tracks exist, it is usually necessary to retain the old grade, and this prevents the surfacing of brick with asphalt.

In estimating the future life of a relaid brick pavement it should be remembered that abrasion has become a minor factor where iron-tired vehicles have almost disappeared. Hence the life of brick should be longer than it has been in the past, provided the foundation and the brick are capable of resisting the impact of truck wheels. In brief, the problem is now one of impact rather than of abrasion.

Publicity for Day Labor on Public Work

Editorial in Southwest Builder and Contractor.

National headquarters of the Associated General Contractors of America have taken up the campaign to secure legislation in every state requiring publicity on all public work done by day's labor. A bill is being prepared which will serve as a basis for such legislation. Minnesota has passed a law requiring an itemized account and full information to be published on all public work done by day's labor. A similar bill was passed by the California legislature but vetoed by the Governor will be revived at the next session of the legislature.

The legislation is distinctly in the interests of the taxpayer and we do not see how anyone can logically oppose it. So far as we are aware the only objection worth considering that any public official has ever raised to it has been that his office was overloaded with work and he did not have the necessary help or the money to pay for it to prepare information such as a publicity act would require. Instances where such an excuse would be valid are the exception and not the rule. But it is not an argument against the proposed legislation for we are sure the public will gladly consent to supply the money necessary for proper publicity if any is needed. We are not anticipating, however, that the expense of publicity will cause any drain on the taxpayer for there will certainly not be any increase in the amount of work or the number of jobs which are not put under contract.

In a recent address to Los Angeles Section, American Society of Civil Engineers, President Arthur S. Bent of the Associated General Contractors discussing the subject of contract work versus day labor said:

You will recall the startling contrast between the results of contract work and day labor work by the state's forces in the construction of the California highways. In the joint report of the two great automobile clubs of California you will find the statement that of three hundred contracts done by the state by day labor amounting to seven millions of dollars, the state's accounts showed unit costs on only five. (How long do you think a contractor would last if he did business that way?) On two of these five, the state first called for bids, rejecting them on the recommendation of the engineer who then went ahead with the work by the state's forces. One of these was in Los Angeles county and the other in Contra Costa County, and the record shows the following figures with the unit prices:

	Estimate	Bid	Cost
1	$102,000	$117,000	$160,000
2	43,000	64,000	81,000
Excvt'g	.55	1.10	1.17 per cu. ft.
Conc. ..	4.50	7.50	10.38 per cu. yd.

In the United States Bureau of Public Roads "Study of California Highways" page 172, you will find the following: A study of twenty jobs, ten of which were done by contract and ten by the state's forces, the contracted jobs exceeded the engineer's estimate by 39 per cent, while the state day labor jobs exceeded the engineer's estimate by 193 per cent. Comment on such a showing as this seems superfluous except to say that it is absolutely typical and could be multiplied indefinitely.

The California highway commission has been doing less work with its own forces during the last year or two and has frankly admitted that when it is possible to do work by contract prefers that method as against day's labor. Much has been said by the commission in explanation of the work done by its own forces. Explanation would not have been necessary had publicity been required on public work done by day's labor. All the information would have been given in detail and would have been accessible to the public.

The California highway commission has probably handled work with its own forces as well as other public officials—state, county or municipal—have done. The quarrel which the public has is with the day labor system. It is not economical, and in only rare instances does it produce results that can be considered satisfactory in comparison with contract work. But the public is entitled to know what it costs to do any public work by day's labor. Further it is entitled to all the facts in the case which have a bearing on the cost and to judge for itself of the results obtained.

Tests for Tractive Resistance of Roads

Experiments with Commercial Vehicles Under Actual Traffic Conditions Described in Iowa Engineer

By W. E. WHITE,
Research Assistant, U. S. Bureau of Public Roads.

In 1919 the Iowa Engineering Experiment Station inaugurated a program of investigation in the field of highway economics with a view to determining all of the cost factors that enter into highway transportation. The program was later correlated with that of the Division of Engineering of the National Research Council and in the spring of 1922 co-operated with by the bureau of public roads.

The first major problem of this investigation was the determination of economical grades for rural highways.

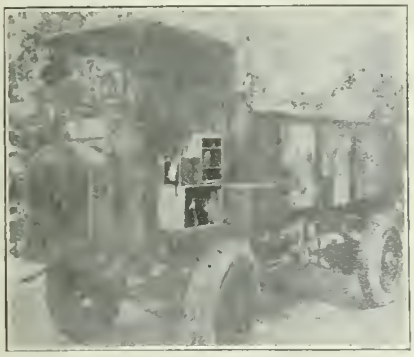


Fig. 1—Space-Time Instrument as Set Upon Truck.

As the investigation progressed it became apparent that tractive resistance is an important factor in arriving at the final conclusions of this problem and the determination of that factor has been in progress for the past several months in a series of experiments.

Definition of Tractive Resistance.—The term "tractive resistance," broadly interpreted, implicates several factors, some of which vary widely with different types of vehicles and some of which vary with the type and condition of the road surface. This investigation is principally for the determination of the latter and for this purpose the following definition has been adopted for tractive resistance.

Tractive resistance is the resistance to translation arising from the interaction of road and vehicle, but excluding resistances in the engine and transmission system. As ordinarily measured this includes wheel bearing resistance and the resistance offered by still air.

Since the results of this investigation were to be applied to actual conditions it was preferable that observations be made under actually existing circumstances. To do this it was necessary that experiments be made on commercial vehicles traveling over typical sections of the desired type of surface and while the surface was under traffic.

Selection of Instruments.—For the determination of tractive resistance the first problem to be considered was the type of instruments best suited for highway work. Instruments were available which had been perfected for similar research on railways, but had not been adapted to highway work where a high degree of accuracy was desirable. The most promising instrument available was the recording spring dynamometer designed and constructed by Prof. J. B. Davidson, head of the agricultural engineering department, Iowa State College.

The dynamometer which records the tension in a towing line gave satisfactory results, but was sensitive to all slight variations in the topography of the surface traveled. This required tedious and time-consuming office work in order that an average value might be determined, and for that reason the use of this instrument was abandoned.

After the dynamometer was found unsatisfactory for this investigation the two other instruments were tried out; the Wimperis non-recording accelerometer and the Drewry testomometer. These instruments are constructed and graduated in a way such that total apparent tractive resistance in lbs. per ton of vehicle may be read direct when the vehicle is coasting on any grade. The ease with which the desired information may be obtained from these instruments makes their use very attractive, but they are sensitive to slight variations in the surface traveled and are difficult to read accurately when on a moving motor truck or passenger automobile.

These difficulties made it apparent that such instruments were not entirely satisfactory and in search of a more satisfactory apparatus, the space-time instrument in use at present was designed and constructed by the engineering experiment station

The Space-Time Instrument.—The space-time instrument is, as its name implies, an apparatus which records distance traveled during successive intervals of time. See Fig. 1.

The recording is accomplished by a set of rolls through which a paper tape is drawn (See T. on Fig. 1) when the rolls are operated by a speedometer cable, A, and sprocket in mesh with a gear on one of the wheels of the vehicle. As the paper is drawn through the rolls it passes under a special pen, marked P, which draws a line on the paper parallel to its direction of travel. This pen is attached to the arm of a relay, R, operated by an electric circuit supplied by a 6-volt storage battery.

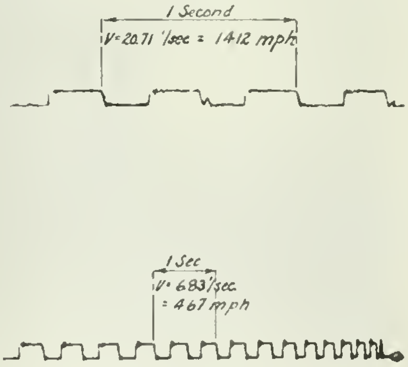


Fig. 2—Two Sections from a Typical Spa-Time Tape Showing Variations in Second of Time.

The fact that the paper travel is brought about by the rotation of one of the vehicle wheels makes it apparent that the paper travel per unit of time has some direct relation to the speed of the vehicle or the distance passed over by the vehicle in the same unit of time. For convenience in computations the unit of time selected is the second and to obtain a time record a clock specially arranged is placed in the relay circuit. This clock, C, is so constructed that when running the circuit closes and opens twice per second. The effect of closing and opening the circuit may be seen from the accompanying two sections of a typical tape, Fig. 2.

The ratio of paper travel to vehicle travel is determined by causing the vehicle to pass over a known distance and measuring the corresponding length of paper travel. This gives a constant which is applied to determine the distance passed over by the vehicle in any second when the paper travel for the corresponding second is measured on the tape.

As an incidental device on the space-time apparatus two electrodes are located opposite the pen, with one on each side above and below the paper tape. These electrodes are in a secondary high-tension circuit supplied by the spark coil, marked S, Fig. 1, the primary circuit of which is supplied by the 6-volt storage battery. When this primary circuit is closed the high-tension spark passes through the tape, leaving a small hole. The purpose of this incidental apparatus is to mark any desired happening or condition during a test, for example, a change in grade or rough place in the pavement.

For making individual test runs with the space-time instrument it is most convenient for computation that the runs be made on a constant grade. For this reason a typical section of the surface under test is selected where the grade is constant.

Where a course can be had of such grade that the vehicle will coast and accelerate from a low velocity to a high velocity, the individual runs or tests are made in one direction only. If the course is of slight grade, such that the vehicle would coast from a high velocity and accelerate to a zero or low velocity when coasting in either direction the individual runs are made in both directions.

When runs are made on the steeper grades the vehicle is brought to rest at the top of the grade and allowed to coast over the course. When courses of slight grade are used the vehicle is brought up to full speed, either under its own power or by towing, at one end of the course, and allowed to coast over the course. When operating under its own power the vehicle is allowed to coast declutched, and when being towed it is allowed to coast free from the towing vehicle.

From the definition previously stated for tractive resistance, it is necessary that these field tests be made either during a time of no wind or that the wind velocity be recorded at the time of the run. With the exception of a few runs, all of these made by this project have been at times of zero or negligible wind velocity. This precaution obviates the necessity for correcting the results for wind effect.

Supplementary data taken during a series of test runs are: Air temperature, average tire temperature, temperature of the pavement or road surface and temperature of differential lubricant.

The first operation in working up the field data is to measure and record on the tape the paper travel and corresponding vehicle travel for each consecutive second. From these values speed-time curves are plotted to a large scale with time in seconds as abscissae and velocity in feet per second or space passed over each second as ordinates.

Space-Time Curves.—The purpose of these curves is to correct for slight unavoidable errors in tape measurements, and also to obtain speeds for the consecutive intervals of time which do not fluctuate as when taken directly from the tape. Careful observation has shown that the acceleration of a vehicle when coasting is affected by local roughness, and by use of the space-time curve this effect is eliminated from the computations. From the space-time curves the velocity in feet per second is tabulated on log sheets, and from these values the corresponding acceleration in feet per second, per second, may be had, as also the speed in miles per hour. This acceleration is the result of action of some set of forces applied to the vehicle when coasting. When the vehicle was coasting no forces were acting except grade effect or gravity, wind or air resistance, internal resistances and tractive resistance.

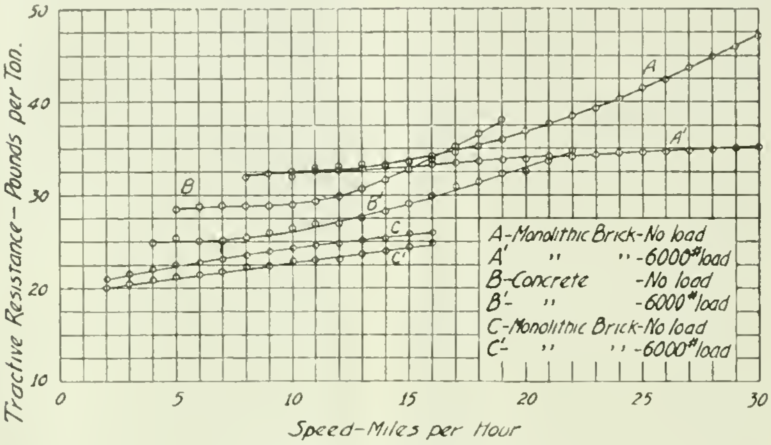


Fig. 3—Six Typical Curves Obtained by Variously Loaded Trucks Traveling on Three Varieties of Pavement.

The results desired may be expressed in terms of lbs. per ton of vehicle weight by the formula, $R=20G$ —($Ma\times 1a2$ divided by r) when R is total tractive resistance, M is taken as the mass of one ton and a is the acceleration of the vehicle in feet per second per second. I is the moment of inertia of the wheels in feet to the fourth power and per ton of total vehicle weight, r is the radius of the wheels in feet and G is the grade of the course expressed in percent, and is positive when the vehicle coasts down grade.

This formula may be more readily understood from the following example: Suppose the vehicle to be coasting down a steep grade. Total resistance=force due to gravity—(force used in producing translational acceleration+force used in producing rotational acceleration of the wheels).

In using the above formula for any specific course it is readily seen that the only variable is the quantity, a, which is computed by interpretation of the data on the tapes.

The last factor in the above formula contains the quantity, moment of inertia (I) the determination of which may appear more or less difficult. In determining this quantity two methods were used for the purpose of obtaining a check and the simplest of these is as follows. The wheel was raised free of the ground and adjusted to rotate with the least possible friction. Weights were fastened to the wheel to balance any heavy section such as the valve stem in pneumatic tires.

A known torque was applied by wrapping a small cord about the hub of the wheel, with a weight suspended from the free end. The wheel was then allowed to accelerate from rest under the action of this known torque and the rate of acceleration noted by use of a stop-watch. From this data the moment of inertia of the wheel and the balance weights was computed by use of the formula $T=Ia$, where T is the torque applied, I is the moment of inertia, and a is the angular acceleration of the wheel expressed in radians. The computed I was later corrected by computing and deducting the moment of inertia of the balance weights which were of known mass at a known distance from the center of rotation. This method contains a slight error due to a part of the applied torque being taken up in overcoming the small, though present, bearing friction. For the requirements of the research this error is negligible and, therefore, no correction has been made.

The total tractive resistance as found from the equation given above contains some factors which must be eliminated to comply with the definition as stated, unless the tests are made under conditions which eliminate these factors in the field. The factor, wind resistance, has been dealt with on this research by making the tests at a time when there was practically no wind and in this way reducing that factor to a negligible quantity.

The factor internal resistance has also been eliminated in a majority of the test runs by use of the F. W. D. truck shown in Fig. 1. This particular type of truck is so designed that power is delivered to the wheels by use of a shaft inside of hollow axles and a "spider" attached to the hub of the wheel just inside the hub cap. This "spider" is easily removed, leaving the wheels free to turn on their usual bearings without moving the transmission system. For that part of the tests which have been made with trucks or passenger cars without eliminating internal resistance it will be necessary to complete supplementary experiments for the separate determination of this factor. Apparatus has been assembled for these determinations and tests for the internal resistance of the vehicles used have been started.

Characteristics of Curves.—Figure 3 is a copy of six typical curves obtained by this research under different conditions as noted. The values given by these curves should not be taken as final for their respective types of pavement, since these curves are from one section of that particular type and any other section of similar type may give slightly different values. For example, notice the different values obtained for monolithic brick by curves A, A^1, and C, C^1. These two courses represented are on the same road, were constructed at approximately the same time and are only about two and one-half miles apart. The principal difference in the two courses being that the course for which the higher values were obtained is on a 5.11 per cent grade, while the other course is of O.O per cent grade.

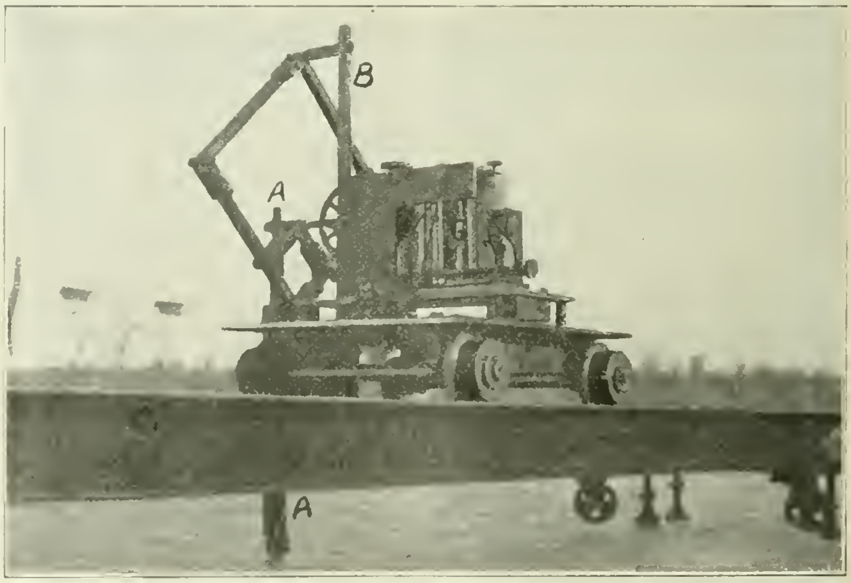


Fig. 4—The Roughness Instrument and the Manner of Its Set-up on a Track, Constructed to Provide for Recording the Unevenness in the Pavement. The Up and Down Movement of the Wheel Is Recorded on the Chart.

The course giving the higher values is also of greater unevenness than the other.

One characteristic of the curves shown in Fig. 3 is that a loaded vehicle shows lower resistance in lbs. per ton than the same vehicle when empty. This fact has been corroborated by parallel experiments on other projects.

Relation Between Roughness and Tractive Resistance.—The effect of roughness on tractive resistance has been evident in the results of several tests and a means for the determination of the relation between roughness and tractive resistance is being attempted. For the purpose of comparing the surfaces of two pavements the roughness instrument shown in Fig. 4 has been constructed.

The purpose of the roughness instrument is to make some comparisons between the detailed topography of two types of pavement or two pavements of the same type, as to their degree of roughness or smoothness. For this purpose the following unit has been selected for use on the local experiments.

The specific roughness of a pavement for purposes of comparison shall be considered as the rise and fall of a roller, 1 in. in diameter, ¼ in. in thickness, with the rim rounded to a ⅛ in. radius, the roller to pass over the pavement in a direction parallel to traffic. The smallest rise or fall measured shall be 1/16 in. and the total rise and fall to be expressed in inches per 100 lin. ft.

The track on which the instrument is to travel must necessarily be of smooth surface, rigid and portable. For this purpose two 3-in. I beams are constructed in two sections and equipped with leveling screws.

In setting the track on reasonably smooth pavement the ends of the rails are set at the same distance above the pavement. For pavement surfaces which are wavy or have appreciable sags or rises the rails are set at the same grade as the course under test, with an engineer's level.

Instrument for Determining Roughness.—The roughness instrument may be divided into two separate parts, the function of each part being a distinct performance. See Fig. 4.

The roller spoken of above is fastened at the end of a rod or plunger, A, which is actuated up or down by the roller rising or falling to pass over bumps or depressions. This plunger, A, is attached to the shorter side of a pantagraph which multiplies the vertical motion three to one and transmits it to a second plunger, B. To the plunger, B, is fastened an arm with a special recording pen attached, which arm works by use of a straight line motion, so that the pen passes up or down over and at right angles to the paper. The straight line motion is of a ratio one to two, which makes the vertical scale of the profile one and one-half to one or one and one-half inches on paper equal to 1 in. The horizontal motion of the paper is accomplished by the use of a train of gears, G, operated by a stationary belt fastened to the rail. The horizontal motion of the paper is such that one foot of paper travel is equivalent to 6 ft. of pavement.

The rise and fall of the roller is recorded by use of a counter actuated by a train of gears and a pinion in mesh with a rack on the plunger, B. The gear ratio of the train is such that one-sixteenth-inch motion up or down is the least registered by the counter.

At the end of a section under test the total rise plus the total fall is read from the counter in sixteenths of an inch.

For the usual course of pavement an average value is obtained by taking four 100-ft. strips, two in each of the tracks followed by the vehicle used in making the tractive resistance runs, and so spaced as to obtain an average value for the entire course.

At the present no definite relation has been established between the tractive resistance offered by a pavement and the roughness of its surface.

Series of tractive resistance tests have been completed in the field on all of the common types of hard-surface pavements as well as on gravel and earth roads.

New Cross Section for Illinois Concrete Pavements

As a result of the Bates Road Tests the Division of Highways of the Illinois State Department of Public Works and Buildings has adopted a new cross section for the concrete pavements contructed under its direction. The tests showed that the strength of the edges of any rigid pavement, built in accordance with any design heretofore used, is much less than the strength of the interior portion of the slab. They further disclosed the fact that a center thickness of 6 in. or even perhaps 5 in. is ample to support the legal load limit provided by Illinois statutes. The new cross-section takes advantages of this fact. The tests further indicate that even with a 6 in. thickness for the main portion of the slab, a 7 in. edge with the ¾ in. longitudinal bar would still not be as strong as the mid-portion of the slab. The edge thickness has, therefore, been increased.

The new cross-section provides for a thickness of 9 in. at the edges of the pavement, tapering to 6 in. at a distance of 2 ft. from the edges. The remainder of the pavement is to have a uniform thickness of 6 in. The amount and arrangement of reinforcement is to be the same as that heretofore used, with the exception of the center-joint material, a new design for which has been provided to correspond with the 6-in. center thickness.

The new cross-section provides 1 sq. ft. less of cross-sectional area than a slab having a 7-in. uniform thickness. This means that the new cross-section will require 195½ cu. yds. less of concrete per mile of pavement than the standard 7-in. design heretofore used.

The department believes, therefore, that the new cross-section will provide a pavement which not only is better able to support trucks loaded to the legal limit, but will also reduce the cost per mile.

The department states that at first sight, it might seem that the cost of shaping the subgrade to accommodate the new cross-section would be troublesome. A little consideration, however, will indicate that the extra cost would be very small, as subgrading machines may easily be adapted to cut the subgrade to the new form. Even should the subgrade be cut to the usual crown, at an elevation 6 in. below the top of the forms and the dirt along the edges is then thrown out by hand, it may be seen that the additional cost of shaping the subgrade would be but a small item.

Maintenance Cost of 11-Year Old Bituminous Macadam at Portland, Me.

The maintenance costs of three sections of state highway constructed in 1908, 1909 and 1910 in the city of Portland, Me., are given in the annual report for 1921 of Edward M. Hunt, Commissioner of Public Works of Portland. The first section, completed in 1908, consists of bituminous macadam (penetration method) laid on Danforth and Vaughan Sts. for a total length of 2,829 lin. ft. The yardage is 8,657 sq. yd. Section 2 covers 2,683 lin. ft. of bituminous concrete (mixing method) laid on Vaughan St. in 1909. The total yardage is 8,807. Section 3 also is bituminous concrete. This was laid in 1910 on Cumberland avenue. The total length of the section is 1,702 lin. ft. and the total yardage is 6,398. These pavements are maintained by the city. The cost of this for the period since the pavements were built has been as follows:

SECTION 1—BITUMINOUS MACADAM, LAID IN 1908; ORIGINAL COST $1.13 PER SQ. YD.

Date.	Repairs.	Surface treatment.	Total maintenance.	Total repairs and maintenance per sq. yd.
1908..	.....	....	....	......
1909..	$ 90	....	$ 90	$0.0104
1910..	293	$306	600	0.0691
1911..	69	246	315	0.0363
1912..	72	157	230	0.0266
1913..	95	96	192	0.0223
1914..	98	100	198	0.0229
1915..	60	126	187	0.0217
1916..	105	...	105	0.0122
1917..	179	232	412	0.0476
1919..	306	122	429	0.0495

SECTION 2—BITUMINOUS CONCRETE. LAID IN 1909; ORIGINAL COST $1.03 PER SQ. YD.

Date.	Repairs.	Surface treatment.	Total maintenance.	Total repairs and maintenance per sq. yd.
1909..	....	....	.....	......
1910..	$ 332	....	$ 332	$0.0378
1911..	99	$406	506	0.0575
1912..	1,340	66	1,406	0.1597
1913..	1,055	37	1,092	0.1240
1914..	98	152	250	0.0284
1915..	50	208	258	0.0294
1917..	24	89	113	0.0128
1920..	...	83	83	0.0095

SECTION 3—BITUMINOUS CONCRETE, LAID IN 1910; ORIGINAL COST $1.31 PER SQ. YD.

Date.	Repairs.	Surface treatment.	Total maintenance.	Total repairs and maintenance per sq. yd.
1910..	....	....	.....	......
1911..	$ 104	$447	$ 552	$0.0863
1912..	449	....	449	0.0702
1913..	761	....	761	0.1190
1914..	312	165	477	0.0747
1915..	292	113	406	0.0635
1916..	256	109	366	0.0573
1917..	102	357	459	0.0718
1919..	115	...	115	0.0180
1921..	1,753	...	1,753	0.2740

Destruction of Road Signs

From the Oct. 14 Nevada Highway News, a bi-weekly publication of the State Highway Department.

The sign vandal has made his appearance along the State Highway System as indicated by the destruction of warning lights, and target practice at metal signs. In one or two instances the red-light danger signals near the railroad grade crossings on the Reno-Carson highway have been wantonly destroyed, thus imperiling the lives of passing motorists who expect the red flashing signal warning them to drive slowly. Destruction of road signs is usually blamed on the small boy with a gun, who has a penchant for target practice, but oftentimes, we venture to say, it is the outcropping of the innate desire for destructiveness of the male species far beyond the boyhood stage. Most of the counties have a standing reward for the apprehension of the road-sign vandal. All maintenance patrolmen are instructed to report all such vandalism to the department and prosecutions will follow whenever possible.

Present Practice in Street and Sidewalk Design

Summary of Various Features Based on Replies to Questionnaire Sent Out By Committee of American Society for Municipal Improvements

In its report submitted last month at the annual meeting of the American Society for Municipal Improvements, the Committee on Street and Sidewalk Design, of which E. R. Conant is chairman, gives an interesting summary of the practice now in vogue in the design of streets and sidewalks. The summary is based on information secured from 60 odd municipalties in various parts of the United States and Canada. Tne report follows:

In making a study of street and sidewalk design certain fundamental principles are to be considered, the most important being utility, appearance, safety, drainage, and arrangement. That full advantage can be taken of streets and walks sufficient widths should be provided for traffic and crowns and grades provided that will least impede traffic.

The relative position of roadways, walks and parkways enter into the utility and appearance feature, and the location of trees, lamp posts, hydrants and poles can be arranged either to mar seriously the appearance of a street or, if the posts, railway poles, etc., are of ornamental design, and properly located, they with the trees or shubbery can add to the general appearance.

The type of curbing and method of laying it adds or detracts from the general appearance. The safety features require consideration of safety islands or zones. For foot traffic the elevation of the curb at crossings should be properly adjusted and with the present fast moving traffic proper curvature of the curb at corners is required.

So that surface water upon the streets can be properly taken care of, the arrangement and type of catch basins or inlets are important. Again the arrangement and layout of roadways, sidewalks and grass plats should be considered with a view of widening the traveled roadway area if found necessary to accommodate increasing traffic.

It might be said that only of comparatively recent date has the subject of street and sidewalk design been attempted in a scientific manner, for comparing the data received in the answers to the questionnaire sent out by the committee, it is noted that with the exception of recent layouts in the older cities, street design in them is far behind that followed in the newer cities. Not long ago comparatively narrow streets were suitable for horse drawn vehicles and with the introduction of street car lines, space bad to be provided for them, but not until the automobiles came into existence did the engineers and municipal authorities realize that the laying out of streets to care for motor traffic was a real engineering problem that had to be treated in a scientific manner.

It is not at all improbable that surface street car lines, except under certain conditions, will to a very large extent, in the near future, be eliminated, and a new method of transportation will arise which will utilize some type of motor bus and undoubtedly new requirements for roadway area will then be required.

Today there are cities and towns located between large cities, between which there is a very heavy truck traffic, which are forced not only to design and adopt types of streets for their local needs, but also to provide for the through traffic. We recognize the fact that types of thoroughfares for a residential city may differ from those required for a mill or manufacturing city. Again, topography enters into the design of our streets so that it is very difficult, if not impossible, to recommend fixed types of thoroughfares that may be wholly standardized.

Width of Streets.—Considering design of streets upon what basis can we determine the proper and necessary width for the traveled roadway? Replies to this question from officials of municipalities show conclusively that the width of roadways should be based on the number of lines of traffic which they mast accommodate and while but a very few cities report that they give consideration to the density of traffic as an aid in establishing the necessary number of lanes, but instead generally allow certain widths for each line of traffic, yet the committee feels that a study of the present and prospective amount of traffic is very important and urges that more study be made of this particular feature in establishing present and prospective needs for vehicular traffic.

Widths of Lanes of Traffic.—Analysis of the replies received would indicate that for each line or lane of traffic a width of from 7 to 8 ft. is necessary for motor vehicles parked at the curb and from 8 to 10 ft. for vehicles moving. The greater width is for truck traffic, the lesser for automobiles so that for industrial or business sections a somewhat greater average width should be adopted for each lane of traffic than for the residential section. A reasonable width for each moving lane of traffic should be not less than 9 ft. and at this time it need not be above 10 ft. For parking vehicles 8 ft. is ample. Space for street car tracks should be from 8 to 9 ft. for single track and from 18 to 20 ft. for double track.

Widths of Roadway.—With the intensity and character of traffic known the total required width of the traveled roadway is readily ascertained. It is observed that the newer cities of the West, South and Canada have generally wider thoroughfares than are found in the older cities. For streets where two lanes of traffic are required, the width of 18 to 20 ft. is pretty well established. For three lanes of traffic 27 ft., for four lanes of traffic 36 ft., and where a single track exists 10 ft. is allowed and for a double track, 10 to 20 ft.

In the larger cities radial and main thoroughfares should be provided for and generally the distance between these main thoroughfares for residential section should be from 1,500 to 2,500 ft. apart and for industrial and business sections they can advantageously be laid out for 600 to 800 ft. apart, this spacing being the practice carried out in the cities from which the committee received answers to their questionnaire.

Lanes or Back Streets. Lanes or back streets are of much importance and directly enter into the utility feature. With a system of lanes, especially with a city laid out with the rectangular system, lanes are of special value. The sanitary sewers can be placed in them. Many of the unsightly poles from the street are placed in the back sstreets, deliveries to residences can be made, and collection of garbage and rubbish as well. Garages constructed on the back of lots can be entered from back streets much better than from the front. The widths of these back streets or lanes should not be less than 18 ft. and preferably from 20 to 22 ft. for they must accommodate two ianes of traffic and provide space for poles.

Street Classification. Classification of streets in some instances are spoken of as major, secondary and minor streets, in other cases as boulevards, main and minor system and lanes. When it comes to considering boulevards local conditions and topography enter into each individual case and where extensive boulevards are planned, the landscape gardener should be a party with the engineer to lay it out. Your committee does not attempt at this time to standardize the layout of boulevards.

Sidewalks.—There must be considered the proper width for foot traffic. Sidewalks in many instances in the past have been laid out irrespective of actual or future needs. The width of sidewalks should be determined by the intensity of traffic, and, from the replies received, the best practice at this time is to adopt a width of from 5 to 6 ft. for residential sections, and from 10 to 15 ft. or more for business sections, the widest walks being called for in the retail business section. The width for walks through parkways or boulevards are often laid out for appearance as well as to meet actual needs, and the width noted above are not applicable to these conditions.

Grass Plats.—The introductions of grass plats or parking space, especially for residential sections, is highly important. Not only does this space offer a suitable location for trees, poles and hydrants, but also enters into the general appearance of the highway and also affords an opportunity, when properly laid out, to permit of widening of the traveled roadway without the acquisition of additional land. The width of a plat where trees are planted should not be less than 5 ft., and the maximum width is fixed for local conditions and by the width of the right of way.

In laying out sidewalks and grass plats a number of cities allot from 1 to 2 ft. on unoccupied space between the sidewalk and the property line when the grass plat is next to the curb. In a minority of the cities from which data have been obtained, the sidewalk is placed next to the curb, and the area between the sidewalk and the property line alloted grass plats. This is with a view, in some instances, of prospective widening of the roadway.

Planning of Streets, Thoroughfares and Lanes.—The general layout of streets, lanes and main thoroughfares is a study for Planning Boards or Commissions and is more for the City Planning Committee to report upon than Committee on Street Design. After the streets or their general location are laid out, the width that should be required is for our committee to study and, as noted above, this study should be based upon the amount of present and prospective traffic to be accommodated. In many cities width of streets are determined by ordinance, some of which are of long standing and the dedication of the streets fixes the widths without any regard to the amount of traffic which they will be required to accommodate.

Safety Zones.—The general practice is to paint the pavement with lines which designate the area or zones where vehicular traffic must give way and look out for foot traffic. These lines may mark zones where street cars stop or they may mark crossings for foot traffic from one sidewalk to the other. The zones where street cars are approached are usually 6 ft. in width and of proper lengths, and a safety walk from the middle of the zone to the sidewalk on the side of the street where the zone is marked off is advantageous. In a number of cities a raised area way is constructed either by a plank platform about 4 in. high or a platform of concrete. In other localities posts or stands connected with ropes are installed. However, the question of safety islands or zones is a somewhat mooted one, and at this time there appears to be no general practice. In a majority of cases the zones or islands are marked with paint, and in at least one state, and perhaps others, laws have been passed requiring safety zones, under certain conditions, to be 7 ft. in width.

Sidewalk Crossings.—There is a tendency to get away from the step at the curb to the street at street intersections, especially where the foot traffic is heavy. In the replies received there were one or two instances cited where the reverse is reported. The method followed out is to have either a gutter underneath a flagging or iron plates with the pavement brought up with a warped surface to meet the curb grade. Another is to have the inlets to catch basins on each side of the corner and the pavement brought up solid to the curb. Where steps are provided, the height or maximum drop should not exceed 6 in.

Curb Radii at Street Corners.—Before the introduction of the automobile and motor trucks, when vehicular traffic was carried on with a much lower speed, a 6, or at most 8, ft. radius curb was considered adequate. Under present conditions in new layouts the radius of the curb in residential sections should not be less than 10 ft. In business sections, from 10 ft. to whatever limit can be introduced, according to width of sidewalk and roadway. For alleys, 5 to 6 ft. radius is sufficient. Some cities have established the radii as being equal to the width of sidewalk at the street intersections, and where the width of sidewalks is greater on one side than on the other, the maximum width would be taken by determining the adopted radius of the curb. Other cities regulate the radius of the curb by the width of the roadway, the narrower streets calling for a greater radius than wider thoroughfares.

Catchbasin Inlets. — Catchbasins should be connected directly to sewer through manholes; that is, an individual pipe should be carried to the manhole from each catchbasin or inlet, and they should never be connected direct to the sewer except at manholes. They are generally located at street intersections, but where necessary to increase the number, intermediate inletss may be located in the middle of the block. One reply received from Winnipeg states that the catchbasin inlets are almost entirely located in the center of the block, the grades of the streets being flat. The gutters run to the center of the block and pavement at street intersections is leveled with the sidewalk. The older system of conducting water from the gutter into the catchbasin was to have gratings in the gutter and perhaps a small opening cut in the curb. Every engineer knows these gratings are a nuisance in that they are continually being clogged up, and many an overflow has been caused by their becoming unserviceable, due to leaves and trash clogging the small openings in the grate bars. Modern practice provides for the entrance of the water into the catchbasin through openings either cut out of the curb, or, better, through openings in castings set in the sidewalk, flush with the curb, under which the catchbasin is constructed, and at street intersections there is no reason why more than one catchbasin should be carried from the gutter on either side to the one catchbasin, and with the latter plan the cross-walk for pedestrians can be brought to the level of the curb at the corner. Many cities have the catchbasins located at the center of the curb radius. In some cases they are placed on the property line back of the sidewalk, but neither plan appears as favorable as to have the catchbasins located back of the end of the curb radii.

Street Crown.—The proper amount of crown is dependent upon the grade, width and character of paving, and to some extent upon the method of providing for run-off of water in gutters. Generally the grade varies directly with the width and inversely as the function of the grade of the street. A quite general practice is to fix the crown from 1/60 to 1/100 of the width, depending on the grade and character of service, and from the replies received from one or two of the larger cities, the crown is frequently the width of the street divided by 60, less 1 in. Again, in one of the prominent cities the crown expressed in hundredths of a foot is 1½ times the width of the roadway. Other formula noted is to allow ¾ in. per foot for one-half the width of street, also 1 in. for each 5 ft. of width.

Analyzing the answers in our questionnaire as regards the amount of crown, the following appears to be the general practice where grades of streets are normal and where the surfacing of the pavement is concrete, brick, bituminous or surfacing of light nature:

For street width of—
20 to 22 ft., the amount of crown 4 in.
24 to 28 ft., the amount of crown 5 in.
30 ft., the amount of crown 5½ in.
32 to 42 ft., the amount of crown 6 in.
45 ft., the amount of crown 7 in.
48 to 52 ft., the amount of crown 8 in.

For rough-surfaced streets such as granite block the crown should be increased from 20 to 25 per cent; for macadam or gravel, 50 to 75 per cent, and where the grades of the street exceed 4 per cent the amount of the crown can be reduced in proportion to the grade, from 20 to 40 per cent.

Gutters.—Where very flat grades are encountered the slope of the gutter is often made much steeper than the general crown of the street, and in a number of instances cited the slope or rake for the gutter may be as heavy as 1 to 3 in. to the foot. This prevents pools of water extending out in the street from the gutter, which might occur if the uniform crown of the street was carried to the curb, and especially where there may be slight inequalities in constructing the street surface. Again, a little increase in longitudinal grade or slope in a flat street can be brought about by having this gutter slightly deeper at the catchbasin than it is in the middle or end of the block.

Arrangements of Roadway, Sidewalks and Park Space with View of Prospective Widening of Roadway.—Special instances can be cited, but undoubtedly the best plan followed is where the municipalities have a Planning Board or Commission, who, with the City Engineer, or other official having charge of the highways, co-operate and have such laws and ordinances passed that permit only the laying out of new streets and thoroughfares based upon a plan that not only will accommodate present traffic, but provide for future growth. In many municipalities such laws and regulations are in force which fix the building line back from the street line, so that if the necessity for street widening occurs, it can be done by acquiring additional land, but not requiring the removal, or setting back, of buildings. Not only is it necessary for the municipalities to have control of the layout of streets within the city limits, but it is very well to have a law which will enable the city to have control of the layout of streets as developed by real estate agents and land promoters within a certain defined distance outside the city limits, this being done for the reason that, as the city limits are extended, there will be a regularity and proper uniformity of layout that will conform to the city's street extensions when the limits are extended.

The arrangement of parking space and sidewalks can be so carried out that in case the roadway requires widening, the extra width can be taken from the park or sidewalk space. One instance where a paved street was widened without changing the crown or tearing up any of the pavement, and yet not increasing the depth at the curb, is of interest.

The paving at the new curb line was started at the regular height or distance below the top of the curb and sloped to the edge of the old pavement, making a gutter several feet from the edge of the curb. Before this was done it was thought by some that the method would be undesirable, but it worked out so successfully that a number of streets in the same city were widened in this manner. This method appears rather novel, but might be used in special cases.

Location of Lamp Posts, Poles and Hydrants.—In many cases poles, hydrants or posts are set just back of the curb, but a better practice would be to have them set back from the curb a sufficient distance so that vehicles in parking will not hit them. We know that some automobiles have overhanging tops, and when parking upon streets with considerable crown, there is danger of hitting posts or poles if they are not set back a little distance from the curb. This need not be more than 1 or 2 ft. Where park space or grass plats exist, lamp stands or posts are generally set in the middle of the grass plat.

In conclusion, the committee feels that a start has been made in ascertaining what appears to be the most modern and best practice as regards street and sidewalk design.

Tests of Skew-Arch Bridges

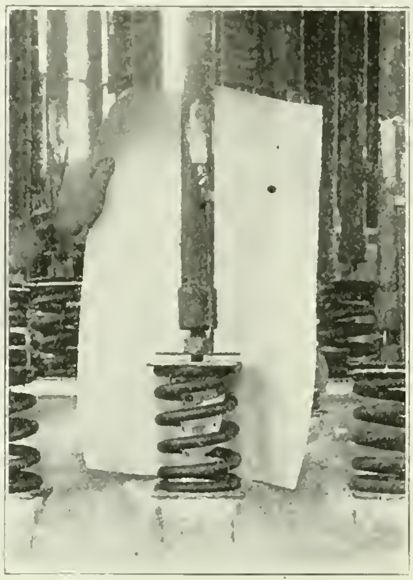
A reinforced concrete skew-arch bridge one-fourth the size of a full-size bridge has been built by the Bureau of Public Roads of the United States Department of Agriculture and is being tested to destruction to gain information that will make possible the building of stronger structures of this type.

The arch is 7 ft. in span, 4½ ft. in width from face to face, and 4 ft. in height above the base of the abutments. The crown or midpoint is 2 in. in thickness and the barrel of the arch is reinforced with ¼-in. bars bent very carefully into the correct shape.

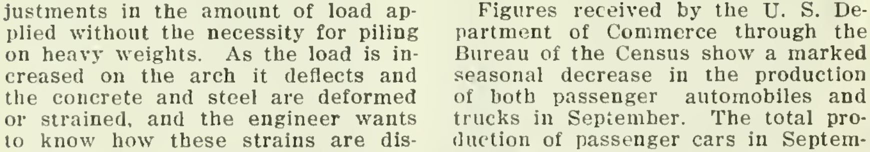
The arch is being tested with a uniform load and this loading is being accomplished in the following manner: Forty-two spiral springs, each capable of carrying a load of 1,500 lb., are placed at uniform intervals on top of the arch and each spring supports a 2-in. pipe, which in turn bears against a solid overhead structure. By adjusting the lengths of these pipes the springs are deflected and the amount of load applied to the arch may be controlled by the amount the springs are compressed. In this way it is possible to obtain fine adjustments in the amount of load applied without the necessity for piling on heavy weights. As the load is increased on the arch it deflects and the concrete and steel are deformed or strained, and the engineer wants to know how these strains are distributed.

For the measurement of strains in the concrete a strain gage is being used. By carefully measuring the strains throughout the arch it is possible to determine the manner in which the stress is distributed and it is believed that through a series of such tests enough information will be obtained to enable the engineer to formulate rules for the economical design of skew arches.

In addition to determining the strains in the arch, the observations include measurements of deflection of the arch under load as well as a measurement of the stress in the tie rods between the abutments.



Arrangement for Applying Load.



Quarter Size Concrete Skew Arch Bridge Under Test.

Motor Vehicle Production in September

Figures received by the U. S. Department of Commerce through the Bureau of the Census show a marked seasonal decrease in the production of both passenger automobiles and trucks in September. The total production of passenger cars in September was 186,562, compared with 249,225 in August, while truck production in September amounted to only 18,843, as against 24,200 in August. The September production is the lowest since last March, but is considerably above the figures for September, 1921, when the total production was reported as 144,669 passenger cars and 13,648 trucks.

The following table gives the total production for each of the last nine months. With a few exceptions, the reports each month are from identical firms and include approximately 90 passenger-car and 80 truck manufacturers. September figures are subject to slight revision when all reports have been received:

AUTOMOBILE AND TRUCK PRODUCTION.
(Number of machines.)

1922.	Passenger cars.	Trucks.
January	81,693	9,416
February	109,171	13,195
March	152,959	19,761
April	197,216	22,342
May	232,431	23,788
June	263,027	25,984
July	224,057	21,357
August	*249,225	*24,200
September	186,562	18,843

*Revised.

Concrete Guards for Highway Embankments

A new type of guard for embankments with steep sloper, developed and tried experimentally in Western Massachusetts by the Division of Highways of the Massachusetts Department of Public Works, is described in a recent issue of the Concrete Highway Magazine by G. N. Willis, assistant engineer of the division.

The guards consist of frustra of concrete pyramids 24 in. square at the base, 12 in. square at the top and equally battered on all four sides. These are cast in place and are set 12 in. in the ground and 30 in. out of the ground. It was thought best to set them no deeper, but leave them so that they would offer considerable resistance to overturning, but not be immovable. The frustra are of 1:2:3 concrete packed with stones up to 8 in. in size. They have been set 5 ft. center to center but the spacing could be increased to 7 ft. and still be close enough to prevent the passage of vehicles between them, or still further increased to 10 ft. and joined by ¾ in. galvanized wire rope passed through eye bolts in their tops.

Concrete Guards on Massachusetts Highway.

The forms are built to come apart easily and can be used repeatedly. The cost has been about $3.50 each or 70 cents per lineal foot of bank protected. The cost can be reduced to 50 cents per lineal foot by using 7-ft. spacing and would be about that amount if the 10-ft. spacing and galvanized wire rope connection were used.

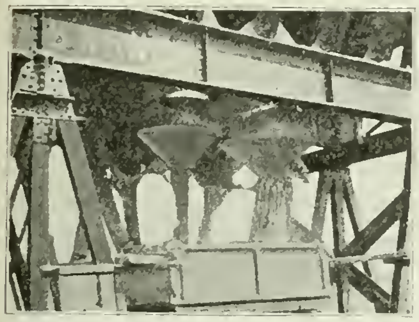
When used on culvert heads, dowels are set in the head to insure a good bond.

Federal-Aid Work in Missouri.—In August Missouri placed 126.7 miles of new Federal-aid work under construction.

Some Construction Features of 13-Mile Concrete Road in Illinois

In connection with the construction of 13 miles of concrete pavement, forming the last link in the 35 mile paved highway connecting Danville and Champaign, Ill., several novel features were developed. These are described by F. C. Feutz, District Engineer of the Illinois Division of Highways in a recent issue of the Concrete Highway Magazine, from which the notes following are taken:

The proportioning plant is of special interest. The sand and crushed stone were unloaded from freight cars by a crane and deposited in a bin constructed entirely of steel, including the supports. The bin was built up of sections of such size that they could be readily handled by the crane. As loose fitting pins held the sections together, neither wrench nor hammer was needed in the erection. The bin could be put up in five hours and taken down and loaded on cars in two hours. It had a capacity of 150 tons or of 200 tons with sideboards on.



Measuring Hoppers Delivered Correct Proportions of Sand and Stone to Batch at One Stop.

Trucks were loaded beneath the bin. The partition separating the sand and stone compartments was parallel to the roadway instead of at right angles to it as in the ordinary bin. This permitted the chutes from each pair of compartments in the bin to be placed over each truck compartment so that the whole load was taken on at one stop.

The measuring hoppers, which have been patented by Mr. Verhey of the Verhey Construction Co., Champaign, Ill., the contractor for the 13 mile section, were especially ingenious. Each one consisted of the frustra of two cones, the lower with a cylindrical section at the base into which the base of the upper fitted loosely. The capacity of the hopper was regulated by the depth to which the upper cone extended into the lower. The hoppers were filled by gravity and measuring was automatic.

A small space was left between the upper cone and the end of the chute from the bin. A flat sliding plate, operated by a lever, closed the end of the chute after the flow of material had stopped. Operation of this gate was made easy by placing it in an uninclosed space so that it only had lose stone to push aside. A "V" shaped opening was left in the chute from the bin so that this stone also was loose. This arrangement worked so well that the gate could be closed by the pull of one finger. A flap valve closed the bottom end of the hopper and could also be used to distribute the materials in the compartments of the truck. Trucks were loaded in 8 seconds.

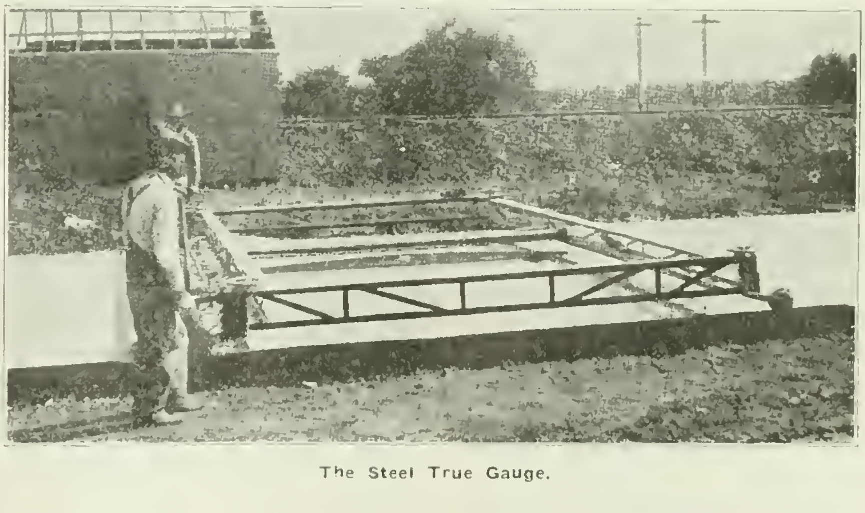
Materials were hauled from the proportioning plant to the 21E Rex Paver in 2-cylinder Autocars, and the pavement was finished with a Lakewood finishing machine.

Illinois specifications, like those in many other states, require that surface inequalities of the finished pavement as disclosed by a 10-ft. straight edge shall be less than ¼ in. The proper time to test for evenness is just before the concrete has become so hard that correction is impossible. If the tester walks on the concrete he will leave footprints which are difficult to remove. If testing is done while the pavement still is soft, the straight edge sinks into the concrete and unevenness cannot be detected. To overcome this difficulty Mr. Verhey designed and patented a device for straight-edging. It consists of a frame made of two steel finishing bridges fastened 10 ft. apart and supported at each corner by a wheel which travels on the side forms. The straight edge is suspended from a shaft whose ends rest on a track on each bridge. The shaft may be pulled back and forth across the pavement with a cord, and another cord drops the straight edge to the surface of the concrete.

In operation the straight edge was dropped to the pavement from edge to edge at intervals of about 3 ft. while the operator watched for inequalities. Any high spots were removed or low spots filled and the device was moved ahead half the length of the straight edge.

A finishing belt, operated by a hand lever, is a part of the device. A tamping template also is to be added and the whole will be operated by a gasoline engine which will move the frame forward. The clutch will be automatically thrown out each 5 ft. the machine moves so that the straight edging will always overlap one-half the length of the straight edge.

The soil on which the pavement was built was so hard and lumpy that it made very poor curing material. The cost of digging, pulverizing and spreading this earth on the concrete was 4½ cts. a square yard. Straw was tried as a covering material and reduced the curing cost to 1½ cts. a square yard and straw was then used to complete the job.



The Steel True Gauge.

Water for curing and mixing was obtained from a well 3 ins. in diameter and 114 ft. deep. A reservoir was made by digging a hole 25 by 40 ft. and 5 ft. deep and plastering the bottom and sides with cement mortar. A 2-in. pipe carried the water to the mixer and the curing gang.

Two "Cletrac" tractors pulling Fresno scrapers handled any earth moving required in the fine grading.

The average crew included about 55 men in addition to the rough grading gang. Whenever 1400 sq. yds. of concrete were laid in one day every man was given a bonus of wages for two hours overtime. When 1600 yds. were laid every one received three hours overtime. As a result the men were as interested in making good progress as the contractor himself and the labor turnover was small.

Suggestions for Patrolmen

The following suggestions on road maintenance in Colorado are given by John Stamm, Assistant Superintendent of Maintenance of the Colorado Highway Department, in Colorado Highways, the official publication of the department:

Don't try to float when road is frozen. Use your blade.

Don't bother with snow when under 2 in. deep.

Don't get too close to gravel when removing snow.

Don't let your road get rutty. Use your blade.

Don't let your ditches and culverts get clogged. Drainage is necessary.

Don't try to float with the wheels of grader. Use the blade.

Don't try to cover your road in one round. It can't be done.

Don't kill the job in order to fatten your horses.

Don't let the sod grow on the brim of your road. Use your blade.

Don't forget you are responsible for the condition of your section.

Don't travel the same way with your drag. Reverse every three or four trips.

Don't forget to drag the center or crown every few days.

Don't forget to drag the gutters. It stops the weeds from growing.

Don't forget to treat the taxpayers as you would like to be treated if you were paying the bills.

Don't think you are not doing any good when dragging the road when it is dry, because you are. Drag, drag, drag and keep your road in shape to take the moisture when it comes.

Costs of Grading Operations

The following analysis of the costs of grading operations is reprinted from The Constructor. The data were furnished that publication by the Mid West Railway and Highway Builders' Association:

"In the bidding for work there is a tendency on the part of the grading contractor to guess on the price for which he can do certain pieces of work. This, in the long run, even if he is generally lucky, will cause him to come to grief.

"A contractor in bidding work should absolutely disregard the prices that work has gone for prior to the job on which he is bidding, and should then consider how much dirt he can average per month for the entire season under all conditions. In putting the price on the work he should then consider what the cost of operation will be on the work.

"One of the members of the Mid-West Railway & Highway Builders' Association, who is also an engineer, has submitted a very close analysis of this cost of operation, which has been gone over carefully, and the only thing wrong with it is that in some cases it is believed that the costs are low:

INITIAL COST OF ELEVATING GRADER OUTFIT, 1922.

Tractor Outfit.

Tractor	$6,050.00
Stock, 30 head	4,500.00
Wagons, 8	2,160.00
Machine	1,400.00
Harness and collars	900.00
Camp equipment	2,500.00
	$17,510.00

Stock Outfit.

Stock, 40 head	$6,000.00
Wagons, 7-3 up	1,890.00
Machine	1,400.00
Harness and collars	1,200.00
Camp equipment	2,700.00
	$13,190.00

"Inasmuch as there are probably a few more stock outfits than tractor outfits, we think you will all agree that $15,000 is about the average price of a grading outfit.

DEPRECIATION ANNUALLY.

	Per cent.
Tractor	30
Canvas	50
Wagons and harness	25
Machine	20
Stock—age and loss	30

"In view of the above, we think you will agree that 25 per cent is low for an average depreciation.

"**Fixed Annual Charges.**—We now have the following fixed annual charges which should be considered as a dead expense and prorated over the eight months of the working season.

Depreciation, 25% of $15,000	$3,750.00
Interest on $15,000 at 7%	1,050.00
Wintering outfit (low)	800.00
	$5,600.00

$5,600.00 for 8 months is $700.00 per month dead expense.

"**Cost of Operation.**—Cost of operation per month, board figured at $25 per month, which is low:

Machine or tractor driver	$ 165.00
Plow holder	175.00
Teamsters, 9 at $3 per day for 20 days	540.00
Blacksmith	100.00
Sloper	65.00
Corral man	100.00
Feed and gasoline	700.00
Freight and incidentals (low)	200.00
Dumpman	100.00
	$2,145.00
Dead expense as above	$ 700.00
	$2,845.00
20% to cover profit and wages of foreman or owner	569.00
	$3,414.00

"**Monthly Yardages and Corresponding Prices.**—Following is a table showing the quantities necessary to be moved at certain prices to earn this figure per month:

Yards per month.	Price per yd.
10,000 cu. yd.	$0.342
12,000 cu. yd.	.284
14,000 cu. yd.	.244
15,000 cu. yd.	.2277
16,000 cu. yd.	.2134
18,000 cu. yd.	.1895
20,000 cu. yd.	.171
22,000 cu. yd.	.155
24,000 cu. yd.	.142

"The $569, as shown for wages and profit, only covers the eight months that he works. Spread over the twelve months it amounts to $379 per month, which is pretty poor wages and profit, considering what he has to go through to earn it."

Accidents in Mineral Industry in 1921

Accidents in all branches of the mineral industry in the United States, including coal mines, metal mines, quarries, coke ovens, and metallurgical plants (except iron-blast furnaces) resulted in the death of 2,367 men in 1921, according to figures compiled by the Bureau of Mines. In 1920, fatal accidents in the same industries amounted to 2,984. Nonfatal injuries at coal mines are not reported to the Bureau of Mines; for all other mines, quarries, etc., the number of employees injured was 35,416 as against 56,057 in 1920.

Accidents at coal mines killed 1,973 men as compared with 2,271 in 1920; at metal mines 230 men were killed and 18,604 injured, as against 425 killed and 32,562 injured the year before; at stone quarries 120 men were killed and 10,465 injured, as compared with 178 killed and 11,217 injured in 1920.

While these figures indicate a reduction in fatal and nonfatal accidents as compared with 1920, there was an increase in the number of accidents per thousand men employed. The fatality rate for all workings combined was 3.59 per thousand employees (on a standard basis of 300 working days per year) as against 3.29 the year before; while the injury rate for all plants (except coal mines) was 192.69 per thousand employees as compared with 184.12 in 1920.

The increase in accident rates per thousand men employed may be largely attributed to the part-time operation which prevailed in the mining industry in 1921, since periods of idleness or intermittent work are generally followed by an increase in accidents.

The total shifts worked by all employees was 197,560,952, a loss of about 27 per cent from the preceding year. Each employee averaged only 189 working days as compared with 249 in 1920. Coal-mine employees averaged only 173 days, a loss of 57 days per man as compared with 1920; employees at iron mines worked 210 days, a loss of 85 days each; copper-mine employees averaged 244 days, a loss of 73 days each; employees at stone quarries averaged 233 days, a loss of 34 days per man.

Cross Drain Construction on Concrete Roads

A method of drain construction that has proved successful on small cross drains is described as follows in The Highwayman by Louis L. Coudert, Jr., assistant engineer of the Union County, N. J., Board of Freeholders:

Construct the bottom and sides of the proposed cross drain leaving the top off where the pavement crosses it. The top of the sides of the cross drain are brought to the elevation of the sub-grade. Two inch planks are placed on braces of 2x4s on 2-ft. centers, so that the planks are level with the top of the drain. Over the planks is placed a layer of tar paper to prevent the concrete from leaking through.

This permits the pavement to be cast over the cross drain in a monolithic slab, eliminating any differences in elevation, a difference in the crown and two construction joints. Extra reinforcement is usually placed over the drain, making two layers of wire mesh or reinforcing bars at this point.

After the concrete pavement is set, an iron bar a little over half the width of the pavement in length with a hook on it will dislodge the 2x4 braces holding up the 2-in. planks. The planks can then be removed very easily.

In order to eliminate the possibility of cracks, the bottom and sides of the cross drain should be laid at least 21 days before the pavement is put on it, as to allow time for shrinkage and settlement of the cross drain.

Where iron plates are used the same general method can be pursued as in a reinforced concrete cross drain, except only the bottom is put in. The forms for the sides are then placed and the plates put on the top of the form. Concrete is then grouted around the plates, giving the plates a firmer bearing than it can possibly hope to get when the entire form is cast and plates fitted afterwards.

Floating Scaffold Speeds Up Water Tank Erection

To speed up the inside work on the erection of a 1,000,000-gal. steel tank 130 ft. in height, as well as afford protection for the workmen, the Chicago Bridge & Iron Co. used a floating scaffold carried on empty barrels. The tank was erected at Asbury Park, N. J., for the Monmouth County Water Co. The raft arrangement is described in Successful Methods.

After the tank reached a height of about 30 ft. water was turned in and the scaffold floated. The scaffold allowed the riveters to work; made the job of moving the gin-pole easy and prevented the men from falling, as there was nowhere to fall.

The tank, which is 35 ft. in diameter, is made up of sheets 6 ft. by 20 ft., each weighing about 2½ tons. These sheets were raised by means of a gasoline hoist and a gin-pole. The pole frames into the sheets. Two stiff legs or braces also frame into bolt holes of the sheets. On the outside a rolling cage carried the heater and bucker-up. There were 6 sheets to a ring and the record day's progress was 2¼ rings.

The scaffold also was used in painting the inside of the tank. Starting at the top a strip of about 7 ft. was painted; water was then lowered about 7 ft. It was necessary to wait about 30 minutes for the surface to dry when the operation was repeated.

The Trend in Highway Engineering Education

A Paper Presented October 26 at the Second National Conference in Education for Highway Engineering and Highway Transport

By T. R. AGG,
Professor of Highway Engineering, Iowa State College.

Prior to 1910 highway engineering instruction was confined almost entirely to the conventional course in roads and pavements. Certain institutions included, in the course of surveying, a few problems in highway or street surveying. In general, there was no attempt to differentiate highway engineering from general civil engineering.

A notable exception existed at Harvard where the late Dean Shaler introduced a few elective highway courses in the civil engineering curriculum. Several engineers who now hold positions of the highest responsibility in the highway engineering field received their training under Dean Shaler.

The reason for the relatively meager treatment of highway engineering during the period prior to 1910 was that the highway problem was principally one of providing for horse-drawn traffic. While there had developed a considerable volume of motor traffic by the year 1908 the percentage of such traffic was small and did not constitute the controlling element in highway design or maintenance.

The rapidity with which the motor vehicle increased in popularity during the period beginning in 1908 was entirely unexpected by highway officials and suitable maintenance methods developed slowly. Many miles of what had been considered adequate roads were seriously damaged before steps were taken to provide real maintenance. An enormous maintenance problem therefore developed within a period of five years, and personnel had to be assembled for supervising the work. Trained personnel did not exist: it had to be assembled and trained. Along with the necessity for maintenance there developed an insistent demand for better road surfaces than could be provided by reconstructing existing roads and for great extensions of the mileage of surfaced roads. These demands also necessitated the employment of personnel technically qualified to supervise the construction of high class types of road surfaces.

By the year 1912, engineering schools had begun to react to the demand for engineers prepared for highway work by increasing the amount of specialized work in highway engineering. Since that time a large number of engineering schools have greatly increased the amount of work required in highway engineering, despite the constant debate as to the desirability of specialization in civil engineering courses. It is doubtless true that the opposition to the inclusion of strictly highway engineering subjects in the civil engineering curriculae arose from jealousy on the part of professors who were apprehensive of a loss of prestige for some of the older established lines of civil engineering.

Three General Plans Being Followed.—A survey of the present practice with reference to highway engineering instruction, among the various engineering schools, indicates that three general plans are being followed:

1. A certain amount of general highway engineering instruction is given through the medium of an elementary course, such as "Roads and Pavements," the amount of such instruction varying from 3 semester hours to 8 semester hours. In some instances the fundamental course is followed by a course in design intended to emphasize the application of the general principles outlined in the previous work. It appears that a large number of institutions follow this plan.

2. A few schools offer a 4 year course in highway engineering carrying a B. S. degree. Obviously such a course includes many subjects that would be appropriate to a standard civil engineering course.

3. Many schools include a fundamental course in highway engineering as a part of the regular work in civil engineering and then offer a certain additional number of subjects as options open to senior students. The amount of required work varies from 2 semester hours to 8 semester hours and the amount of optional work varies from 3 semester hours to 6 semester hours.

Typical required courses are: Roads and Pavements. Highway Design, Road Materials Testing and Highway Bridges.

Typical optional courses are: Highway Administration. Highway Drainage. Highway Specifications and Highway Finance. In some schools certain of the courses listed above as required are optional and likewise some of the courses listed as optional are required, but the general arrangement is as first given.

Character of the Courses.—The content of the several courses varies with the experience of the instructor, but the following indicates in a broad way the usual character of the subject matter.

Roads and Pavements: Types of roads and pavements surfaces, methods of construction and maintenance, elements of design and elementary highway economics.

Highway Design: Problems involving the actual working out of designs for roads and pavements including establishment of grades, alignment and slab thicknesses and the design of such details as curbs, inlets, superelevated curves, intersections and warped surfaces.

Highway Drainage: Application of the theory of land drainage to highway drainage and consideration of the various accepted methods of draining highways and controlling erosion.

Highway Bridges: Application of the principles of structural engineering to the design of bridges and culverts for highway loadings and consideration of the types of structures usually adopted for highway improvement.

Roads Materials Testing: Laboratory work covering the accepted methods of testing non-bituminous and bituminous road materials. Some times supplemented by lectures and recitations intended to emphasize the significance of the results of the tests.

Highway Administration: Highway laws, highway finance, methods of administration, organization of municipal and state highway departments, and organization for day labor and contract highway construction.

Highway Specifications: Critical analyses of current specifications for road or pavement construction and practice in the writing of specifications for specific projects.

Highway Finance: Usually taught by the department of Economics as an exposition of the principles of public finance.

Short Courses.—In order to bridge over the period during which an insufficient number of properly trained men are available for highway work and to enable ambitious men to prepare themselves for advancement, some institutions give intensive instruction in highway engineering during periods of two or three weeks. Courses of this character meet a real need and when the subject matter is well chosen and presented with a regard to the limitations of those in attendance, are of great value. They must be intensive, not too highly technical and must be closely correlated to current highway practice in the area from which the students are drawn.

Highway Engineering Graduate Courses.—A few institutions offer graduate instruction in highway engineering and this field probably is susceptible of considerable development. Under the most favorable conditions it is impossible to go very far into the ramifications of highway engineering during the under-graduate years nor is it probably wise to attempt to do so. Highway research is beginning to receive the attention it deserves and presents a virgin field for graduate study. It follows that highway engineering should, for many years to come, offer an attractive field for engineers who wish to avail themselves of the undoubted advantages that accrue from graduate study.

In order to make available to practicing engineers the opportunity for graduate study some institutions offer the graduate work during a period of six or eight weeks during the winter. This enables engineers to attend during what is usually their slack season. But in any case the graduate courses should be available dur- collegiate year.

Summary.—The trend in highway engineering instruction seems to be toward a system whereby certain fundamental courses are required of all civil engineering students. In general, this amounts to about five semester hours. Supplementing this required work there is offered about an equal amount of optional highway engineering instruction for men who wish to specialize in the subject.

Short courses to fill a passing need have been successful in many institutions. These may extend through a week or through as many as three weeks.

Graduate work in highway engineering is developing rapidly and presents a very real opportunity for educational progress.

Gravel Road Construction and Maintenance

Methods Employed in Iowa Described in Paper Presented at Last Annual Meeting of Missouri Highway Engineers' Association

By C. COYKENDALL,
Assistant Chief Engineer Iowa State
Highway Commission.

The type of improvement most generally practical for secondary road systems is a gravel surfacing or sand-clay surfacing. It has been found during the past ten years that this type of improvement is in general more economical than waterbound macadam and more cheaply maintained under modern traffic. It, therefore, follows that there is probably no problem deserving of more thoughtful consideration on the part of highway engineers than proper methods of constructing and maintaining gravel and sand-clay roads.

In this discussion no fine distinction will be made between gravel and sand-clay construction. Satisfactory results can be obtained with either gravel or sand-clay construction if available material is used intelligently. Given ideal materials, the construction of any type of road is not a difficult problem. It requires a higher degree of engineering ability to get satisfactory results from the most available sources of material, even though such materials may be generally regarded as of inferior quality, than to require ideal materials without consideration as to the availability of such materials, and the resulting construction costs.

It is extremely difficult to determine where the dividing line between the construction of pavement and the construction of gravel roads should be drawn. There are a number of factors that must be taken into consideration in making this determination. Perhaps it would be well to enumerate some of these factors.

Traffic Considerations—First, and primarily, the amount of traffic which must be handled, either present traffic which the highway is carrying, or the traffic that we can reasonably anticipate will be handled as soon as the road is completed. No one can state with any certainty the exact number of vehicles which a gravel road will handle in a satisfactory manner. All know from experience that there are roads on which the traffic can not be satisfactorily taken care of on such a surface. Likewise all know from experience that there are roads of secondary importance where a gravel surface serves every need of the traffic. Between these two points, however, there are many situations which are not so easily classified.

During 1919 and 1920 the State of Iowa in connection with the submission of Federal aid projects, did a considerable amount of traffic census work. Some of the roads on which a traffic census was taken had failed satisfactorily to take care of traffic as gravel roads. The traffic count showed that on the road south from Spirit Lake, which is perhaps the most popular summer resort in Iowa, there was an average daily traffic of approximately 915 vehicles. This road could not be satisfactorily maintained as a gravel road under this traffic. On the Jefferson highway north from Des Moines the traffic count showed an average daily traffic of approximately 800 vehicles. It has been found that this road could not be satisfactorily maintained, either as a gravel road or with a cinder surfacing. On a project in Howard County, which is some distance from the centers of population and carries only the ordinary county seat to county seat traffic, and a very limited amount of through traffic, the traffic count showed an average daily traffic of 238 vehicles. This road has been completed as a gravel surfacing project and is taking care of the traffic in a very satisfactory manner. The same is true of a project in Chickasaw County, where the traffic count showed an average daily traffic of 216 vehicles.

We have reached the conclusion in Iowa that where the daily traffic is not in excess of 500 vehicles per day, we can quite successfully construct and maintain a gravel surface. Where the traffic is in excess of this amount, however, maintenance costs mount rapidly and we are unable to give traffic service that is comparable to the service given by a properly constructed and maintained paved road.

Availability of Materials.—Second, availability of materials for gravel road construction and maintenance; also availability of materials for paved road construction and maintenance.

Availability of materials determines in a large measure the economical type of improvement on any road. Where a good quality of gravel is available locally for gravel surfacing work, it is economical to construct and maintain gravel roads under conditions where it would not be economical if all such material for construction and maintenance had to be transported a long distance by rail, thereby greatly increasing the cost of construction and maintenance work. The real measure of the value of any type of road is the cost per ton mile or vehicle mile to the users of the highway. In determining this cost the availability of materials is an important factor.

Relative Usability of the Two Types. Third, the relative usability of the two types of road.

In considering usability we must take into account tractive resistance, satisfaction and convenience to the users of the road, and the safety of the road. Often we are justified in paving a road that can quite economically be taken care of by some cheaper type of construction, from a consideration of these factors alone. All have had experience in driving over a gravel road where the surface was in good condition, but the dust was so bad that it constituted not only a nuisance, but an actual menace to traffic. All have seen gravel roads, especially during a long-continued dry spell, where the loose gravel which had accumulated at the sides and on the shoulders constituted a real menace to travel, particularly at night when meeting or passing other vehicles.

Experiments carried on by the Engineering Experiment Station at Ames during the past year show that for truck traffic, a good concrete or brick surface requires 20 to 30 per cent less gasoline consumption per ton mile than is required for a road with a good gravel surface. Similar conclusions were reached in a series of tests carried on a few years ago by Professor A. N. Johnson, now with the University of Maryland. Hence it appears that on account of less surface resistance, actual operating costs to motor vehicle users are less on a good paved road than on a good gravel road, and this with other factors that are measures of the usability of a road are worthy of consideration in determining the proper type of improvement.

The Time Element.—Fourth, the length of time that must necessarily elapse before a road can be paved.

It is often economical and expedient to gravel surface a road where traffic conditions will justify pavement in order to provide the traveling public with a usable road until such time as the pavement can be constructed. The building of a system of paved highways, including five thousand to ten thousand miles, is no small undertaking, even after the necessary legislative action has been taken and the necessary funds for financing the program have been provided. It takes time to develop an engineering organization capable of properly handling a large paving program. It takes time to develop sources of material sufficient to take care of a large paving program. It takes time to develop a contracting organization to do the actual work. From our experience during the past two or three years, during which time a large paving program has been under way, we can appreciate the fact that few states are organized to build more than a few hundred miles of pavement each year. The demand of the public is for "usable roads now." Consequently, in many instances, we are justified in producing a large mileage of relatively cheap road which will give road users service during the time that must necessarily elapse before a large mileage of paved roads can be produced.

Legislative Machinery.—Fifth, legislative machinery for building various types of road.

This is really the meat of the whole situation. We can not build roads except as we are authorized to do so by our state legislatures, and are provided with the necessary funds. Consequently in states where we are not authorized to build paved roads and in which funds for financing this type have not been provided, we must build the best type of road that has been authorized and for which funds have been made available.

Referring again to the situation in Iowa we can not build paved roads in any county in Iowa until the voters of that county have authorized the general policy of hard surfacing the primary road system of that county. If we are to make any material progress in those counties that have authorized the paving of the primary road system, a bond issue must also have been authorized. Consequently, in Iowa, we are not in position, in all cases, to build the type of road which should be built from a consideration of the needs of traffic, nor is this restriction peculiar to Iowa alone.

This discussion up to this time has dealt only with factors covering the selection of the type of improvement. We will now assume that we have a road which is to be gravel surfaced, and will give consideration to the details of construction.

Alignment, Grade and Cross Section.—In gravel surfacing primary roads the same consideration as to alignment, grade and cross section applies as in the case of paving. There are many miles of our trunk line or primary road system that should probably be gravel surfaced before they are paved. Without doubt, however, the time is not far distant when this mileage should and must be paved. Consequently in building a gravel road we should attempt to determine upon a location and prepare a design as to grade, drainage structures, and cross section, which will prove satisfactory later on when the road is to be paved. It is quite generally recognized that the maximum grade for primary roads should not exceed 6 per cent, and should be made as much less than 6 per cent as topographical conditions will justify. Horizontal curves should be held as closely as possible to a maximum of 10 degrees. Right angle turns should be rounded with a curve of not less than 200 ft. radius, while a 300-ft. minimum requirement is better. In so far as is at all possible, the element of danger at railway crossings should be eliminated, either by grade separation or relocations of the highway which will eliminate the crossings entirely. The cross section should provide a minimum from 28 to 30 ft. width between shoulders with ditches at least 2 ft. below the shoulder line, and 4 to 6 ft. out from the shoulder line. A flat bottom ditch at least 2 ft. in width should be provided and back slopes made with whatever slope is required to prevent the ditches from filling.

On secondary roads less stringent requirements can be laid down as to grade, alignment and cross section. Grades and alignment should be the best possible to secure giving due consideration to the amount of traffic the road must carry. The cross section will vary between 20 and 30 ft., the limits depending upon the importance of the road, with substantially the same requirements as to ditches and back slopes outlined above for primary roads.

Drainage.—Thorough subdrainage is absolutely necessary to successful gravel road construction and maintenance. It is probably even more essential on this type of construction than on pavement, inasmuch as the road surface itself has so much less inherent strength. Subdrainage can be secured either by the use of tile or by the construction of a grade which will bring the surface of the road well above the ground water limits. In all cases the surface of the road should be at least 2 ft. above the ground water level, and as much more than this as it is practical to secure. It is generally conceded by everyone at all interested in the road program in Iowa that thorough drainage is a primary essential to successful road construction. The people of Iowa are probably more nearly in accord on this point than on any other point in connection with our road building program. In the level sections of the state where natural drainage conditions are poor we ordinarily use more than a mile of tile drain per mile of road. During the 1921 construction season we laid more than one thousand miles of tile drain.

Material Specifications.—Specifications for materials to be used for gravel road construction should be broad enough to admit any graveling material which by intelligent application can be successfully used in road construction. All states are not in accord with this, but, as stated heretofore, we believe that it is necessary to utilize to the fullest advantage the materials that are available. The maximum size of stone should not exceed 1½ ins. If this limit is changed, we would recommend decreasing it rather than increasing it. The amount of binder which the material may contain is extremely variable. As a general proposition the less binder that is used, the better. There are comparatively few instances where it is justifiable to haul binder for any considerable distance, inasmuch as substantially the same results can be secured by incorporating the loam, clay or gumbo of the road into the surface as binder.

The amount of material required per mile of road varies, of course, with the type of road being improved. Ordinarily between 1,000 and 2,000 cu. yds. per mile is enough. More material can be added from time to time as a maintenance measure. Consequently it is not advisable to place as a construction measure so much material that it is a serious problem to traffic properly to compact the material.

Construction Work. — Gravel road construction work is very readily handled as a contract proposition if the specifications are properly drawn. The construction of the grade and the installation of the necessary drainage structures and tile drainage should not be tied up to the same contract as the gravel surfacing. Neither should maintenance by the contractor over any considerable period of time be required. The items included in the contract should be as few and as definite as possible. In our Iowa specifications the contractor bids on the following items: Stripping gravel pits, shaping subgrade preparatory to receiving the gravel, loading the gravel at the pit and hauling it one mile and spreading, and additional half-mile units of haul. The stripping of pits is on a yardage basis with a specified amount of work to be done.

It has been found economical thoroughly to prospect the source of supply before contracts are awarded for gravel surfacing work. From these investigations it is possible to specify with reasonable accuracy the amount of stripping that will be required, also whether or not the material must be screened and oversized material crushed. In the average deposit where there is not a large amount of oversized material, the price bid per cu. yd. for loading includes the removal of oversized material at the pit.

All hauls of less than one mile in length are included in the price bid per cubic yard for loading at the pit, as is also the spreading of the material upon the subgrade. When the haul exceeds 1 mile and is less than 1½ miles the price bid for each additional half mile haul is added to the unit price of loading. Similarly for each additional half mile that must be hauled the unit bid is proportionately increased. This method has been found more satisfactory and less confusing to contractors than bids based on average yard-mile hauls.

Before the gravel is dumped upon the road the subgrade should be flat and smooth. The gravel should then be dumped either on the shoulders or in the center, depending upon the time of year that the work is being done, and then spread the full width of the road. The material in the center should be spread thinly enough that traffic can travel down the center of the highway without serious inconvenience, immediately after spreading operations have been completed. We have not found the use of a roller practical in gravel road construction. Our most satisfactory results are secured by allowing the gravel to be compacted by the traffic, under continuous and intelligent maintenance. By spreading the gravel so thin that traffic is forced to the center, the shoulder lines are not destroyed nor is the element of danger to traffic introduced that is present when the gravel is windrowed down the center and traffic is forced to the shoulder line. As the center becomes compacted under traffic, loose material from the shoulders is worked toward the center of the road and the road gradually assumes the cross section intended, that is, a thickness of 5 to 7 in. at the center line shouldering out to a feather edge near the shoulder line.

It is often found during the process of compacting the gravel that the material used is deficient in binding qualities. Usually this difficulty can be remedied by harrowing, plowing or otherwise mixing the material of the subgrade into the surfacing. It is believed advisable, however, to exercise considerable discretion as to the amount of binder used. Traffic should not be seriously inconvenienced by being forced to travel for a long period over a loose gravel road, but if some patience is exercised, both by the engineer in charge of the work and those using the road, it will be found that a more successful road will result from a sparing use of binder.

Maintenance Should Start at Once.—Under the construction specifications which have been recommended, it is very difficult to state where construction stops and maintenance work begins. As a matter of fact, it is recommended that the maintenance organization take over the road as soon as the gravel has been placed on the subgrade, spread once and thoroughly mixed. The success of any gravel road is dependent very largely on the maintenance. Consequently, as soon as the gravel has been placed a well organized maintenance crew should be in position to take over the road and give it proper attention through the very important stage that it is being compacted by traffic.

For the gravel roads which we can economically build from material available in Iowa, maintenance by a bituminous mat coat or by the application of bituminous materials is not recommended. Many of our materials have too large a percentage of fine material to make this system of maintenance successful. In fact, representatives of commercial interests primarily engaged in the manufacture of bituminous road materials do not recommend the use of such materials on many of the gravel roads in Iowa. This discussion will be limited to maintenance of gravel roads by methods other than by the use of bituminous materials without in any way entering into the merits of the use of such materials where a different type of gravel is available for the construction work.

Gravel road maintenance divides itself quite logically into two operations: First, the maintenance of material placed during construction, and second, maintenance by applying additional material. Both operations are necessary. We must expect to renew from time to time the material which is lost either by the action of the elements or by gradually being forced into the subgrade. On our most heavily traveled gravel roads in Iowa the annual replacement of surfacing material is from 300 to 500 yd. per mile per year.

Patrol Maintenance.—For keeping gravel road surfaces in good condition the patrol system of maintenance is strongly recommended; that is, a patrolman equipped with a patrol blade grader and other incidental tools should have full charge of the maintenance of a certain section of gravel road. The length of this section is dependent upon the importance of the road and the amount of traffic which it carries. For heavily traveled roads ordinarily five to six miles is the maximum which a patrolman can take care of. The surface of a traveled gravel road requires constant attention, regardless of weather conditions. The best results in filling chock holes that develop are secured after it rains, but the prevention of the development of chock holes is dependent largely on the care the road receives during the dry weather periods. If a film of loose material can be kept on the surface of the road, it will be found that this film of material really bears the brunt of the traffic and prevents ravelling of the surface of the road. Naturally if a film of loose material is to be kept spread over the surface, continual attention on the part of the patrolman is required, as traffic tends to whip this loose material to the center and to the shoulder lines.

Gang Maintenance.—The efforts of the patrolman must from time to time be supplemented by what is ordinarily styled gang maintenance. The patrolman is not equipped to do heavy work, such as opening ditches or building up the shoulders. It will be found on a heavily traveled road that from time to time an accumulation of loose material has taken place on shoulders and that it is very difficult to get this loose material to pack in the center of the road. In those cases it is often necessary really to reconstruct the road; that is, the loose material that has accumulated on the shoulders should be forced to the center of the road, the shoulders built up from material taken from the ditches, and the gravel re-spread from shoulder line to shoulder line. For this work, a 12 ft. blade grader drawn by a tractor is very effective. It will be found in this operation that the material taken from the ditches acts as new binder, and that better success will be had in getting the gravel compacted. Quite often this process should be supplemented by the addition of a maintenance course of material. In fact, this process practically always should precede the adding of a maintenance course of material.

Gravel Maintenance of Earth Roads—We experimented in Iowa during the year 1921 with a so-called gravel maintenance of earth roads. That is, an earth road that has been properly graded and drained is given a very light surfacing of gravel—approximately 500 cu. yd. per mile. We have not considered that with this much material we have been building gravel roads, but we have been making earth roads much more usable for eleven months, at least, out of every year. The addition of the gravel to the top soil of the road makes the gumbo soil or heavy clay soil much more easily maintained under heavy traffic. It also makes the surface of the road impervious to ordinary summer rains.

The cost of this kind of maintenance where gravel is locally available is not heavy, and it is expected that on roads where a 500-yd. maintenance course was placed in 1921 an additional 500 yd. will be placed in 1922, and in time we are quite likely to have "maintained" an earth road into a gravel road. Material used for this kind of work should all pass a screen with 1 in. openings. We are much interested in the possibilities of this type of road work and expect to try it on quite a considerable mileage during 1922.

Conclusions.—In conclusion we have these points which should be emphasized in connection with the construction and maintenance of gravel roads:

First, do not lose sight of the importance of this type of construction. For years to come this type of road will undoubtedly constitute the greatest percentage of the surfaced roads that are built.

Second, make the maximum use of available materials. Have your specifications as to materials flexible enough to allow the use of any graveley material which with intelligent construction and maintenance methods can be advantageously used for gravel road construction.

Third, draw the specifications in such a manner that the construction of gravel roads is a readily contractable proposition. Do not require the construction contractor to do a lot of maintenance work for which he has neither equipment nor the experienced organization so necessary for satisfactory gravel road maintenance.

Fourth, do not expect satisfactory results from any gravel road unless thorough and systematic maintenance can be given. A gravel road is no better than the maintenance it receives.

Preservation of Trees Along State Highways.—The policy of the Indiana State Highway Commission is to save trees along state roads whenever possible, and in many instances in order that a particularly fine tree be spared roads have curved slightly. This action is being taken relative to widening State Road No. 1 near Crothersville in Jackson County. Just south of Crothersville an immense maple in front of a country home is too near the right-of-way, but in order to save the big tree which is highly prized as a landmark, the commission has permitted engineers to swing the right-of-way over a little. A large oak standing almost in the center of the road near the same town is to be removed, officials taking the position that it is a menace to traffic.

Mileage of Rural Roads.—There are 2,500,000 miles of rural highway in the United States.

Traffic Regulation for Streets and Highways

The report of the American Society for Municipal Improvements' Committee on Traffic and Transportation, of which Prof. Arthur H. Blanchard is chairman, submitted Oct. 6 at the convention of the society, was devoted to tentative recommendations. In presenting the report the committee requested that recommendations be discussed at the convention and also asked that members interested in efficient traffic regulation and the economic development of highway transport submit criticisms and suggestions relative to the several subjects presented to the chairman of the committee prior to July 1, 1923. It is the intention of the committee to present recommendations relative to these subjects for final adoption at the 1923 convention.

The report follows:

Weights and Dimensions of Motor Trucks.—Members of the society are urged to discuss with the members of their state legislatures the following dimension and weight regulations for motor trucks with a view to incorporating sane regulations in state laws which would be effective in all cities within a state passing such legislation.

Maximum width of motor truck chassis or body, 96 in.

Maximum overall height from base of tire to highest point of vehicle or load, 12 ft., 6 in.

Maximum overall length vehicle, body and load, 30 ft.

Maximum weight per linear inch of width of solid rubber tires, measured at the base of the rubber, 800 lb.

Maximum gross weight on one axle, 22,000 lb.

Maximum gross weight of motor truck and load, 28,000 lb.

In its 1923 report, the committee intends to present recommendations pertaining to trailers and maximum speeds for motor trucks and trailers operating within cities on different classes of streets for different types of motor trucks and trailers.

Financing of the Reconstruction of Streets.—The committee submits, for consideration, the proposal that the cost of reconstructing pavements and foundations on streets in business districts and main through trunk thoroughfares be financed by general appropriations and in no cases of such streets by assessment against abutting property.

License Fees for Motor Vehicles.—The committee asks criticisms of the following tentative conclusion: That no license fees be charged for the operation or ownership of motor vehicles by any city but that all such license fees should be collected by the State and that a certain proportion thereof should be distributed to the cities by the State and be credited to the street maintenance funds.

Franchises for Freight and Passenger Highway Transport Intercity and Rural Express Companies.—The committee tentatively recommends that each highway transport company operating an express freight or passenger service on a definite route and in accordance with a time schedule should be required to obtain a franchise from a state commission, particularly appointed for this purpose, and should be required to secure the permission of all cities through which it operates to use a definitely prescribed route therein.

Sign Posting for Through Routes in Municipalities.—The committee suggests that, at all corners at which turns are made on through routes in municipalities, direction signs be erected and, at the city limit on each route, a large map sign be erected, which will show the plan of all through routes in the municipality, giving the names of the streets and the principal adjoining cities to which each route leads.

Safety Car-Stop Zones.—The committee tentatively recommends that raised car-stop safety zones be universally employed in place of safety zones designated by limit lines, stanchions or mushrooms. It also recommends that no stopping, ranking or parking be allowed at the curb opposite the safety zones and for a distance of 10 ft. each side of the safety zones.

Railroad Grade Crossings Within Municipalities.—Railroad grade crossings are a constant source of accidents. It is evident that their total elimination is desirable, but unfortunately is not practicable in all cases in the present state of the financing of highway improvements. Much can be done by proper design to reduce traffic hazards in the case of railroads crossing highways at grade. A clear sight of the railroad crossing for 500 ft. on each side materially reduces accidents and a clear sight of the railroad for 1,000 ft. on each side of the highway is desirable. The width of all roadways crossing railroads should be at least 20 ft. For a distance of 100 ft. on each side of the railroad, the grade of the highway should be level or not over 2 ft. rise or fall in 100 ft. The suggestion by some officials to construct humps in the highway to slow down traffic approaching railroad crossings is unreservedly characterized as pernicious.

Proper danger signs should be located at 200 ft. each side of grade crossings in municipalities and, in sections which are poorly lighted at night, a large electrically lighted rectangular sign carrying the word "Danger" in red letters should be suspended directly over the center of the street at the grade crossing.

Traffic Regulations for Municipalities.—The committee recommends the adoption, as far as practicable, of uniform traffic regulations for vehicles and pedestrians in municipalities. It is the intention of the committee to present a complete set of fundamental regulations in its 1923 report. In the present report, there is included only regulations relative to which there may be differences of opinion. It is requested that the members of the society discuss these regulations with the chief of police of the city in which they reside and submit suggestions and criticisms to the chairman of the committee prior to July 1, 1923.

Vehicular Traffic Regulations.—No person shall operate an automobile, motorcycle or other motor vehicle on any street or public highway in the business or public highway in the business portion of the municipality at a greater rate of speed than 15 miles an hour or on any boulevard, drive or parkway at a greater rate of speed than 15 miles an hour provided such parkway or boulevard drive shall have signs placed at the entrance thereof to indicate such rate of speed, or on any street or public highway elsewhere in the municipality at a greater rate of speed than 20 miles an hour.

Vehicles turning to the left into another street shall pass to the right of and beyond the center of street intersections, before turning, and in congested districts where traffic policemen are stationed at street intersections, an approaching automobile or vehicle shall signal the officer and shall not pass such officer until receiving proper signal from said officer.

Any person or persons operating or driving any motor vehicle or other vehicle shall, at the intersection of any public street or highway, within the limits of the municipality, keep to the right of the intersection of the center of such street or highway when turning to the right of such intersection.

When vehicles approach an intersection of two or more public streets or highways the vehicle approaching from the right of the driver shall have the right of way.

No vehicle shall turn to proceed in the opposite direction except at street intersections.

A vehicle shall not stop on a crosswalk nor within the intersection of two or more roadways.

No vehicle shall stop on any street, except within 1 ft. of the curb, or in such a way as to obstruct free passage on the street, provided that this rule shall not apply when a driver of a vehicle is compelled to stop for a standing street car.

Drivers of motor vehicles before starting, turning, stopping, backing or changing their course, shall make sure that such movement can be made with safety and shall give definite visible signal of such intention.

No vehicle shall stop anywhere in the city with its left side to the curb.

Each bicycle shall be equipped with a suitable horn or bell for giving warning or signal of its approach and, during the hours when lights on the streets are lighted, shall be equipped with a suitable headlight.

The chief of police may, from time to time, prohibit or regulate the stopping, ranking or parking of motor vehicles or other vehicles in any district where such stopping, ranking or parking will interfere with traffic or the public safety, and no vehicle shall be parked at any time within 15 ft. of any fire hydrant.

Not more than two persons shall occupy the front or driver's seat of an automobile, except that child less than 10 years of age may occupy the front or driver's seat as a third person and no person, adult or minor, shall be seated in the lap of the driver nor shall the driver be seated in the lap of a person when the automobile is in motion.

No motor vehicle having an overall length greater than 20 ft. shall be diagonally or perpendicularly parked at a street curb except when loading or unloading.

Pedestrian Traffic Regulations.—Except where safety zones are established pedestrians shall stand on the sidewalk while waiting for street cars until the street car is within 200 ft. or less from the stopping place and when alighting from street cars pedestrians shall not stand in the street but shall proceed immediately to the sidewalk to the right, except where safety zones are provided.

Pedestrians shall not step from the sidewalk nor from between or back of vehicles in crossing a street without looking in both directions to see approaching vehicles, and shall cross only at right angles with the street.

It shall be the duty of all pedestrians to observe the line of traffic at street intersections and to obey the signal of policemen who are directing the movement of such traffic and they shall not cross before the signal is given for the traffic to move in the direction toward which the pedestrians are crossing.

Pedestrians shall not cross street intersections diagonally but they shall cross only one street at a time, using a crosswalk, if designated, or otherwise shall cross at right angles with the street.

Pedestrians crossing the street in the congested district or the business district or crossing any main thoroughfare, shall do so only at street intersections or crosswalks. Pedestrians crossing any street at a point other than a street intersection or crosswalk outside of the congested district or business district or main thoroughfares shall exercise due diligence for their own protection and safety.

Simple Test for Determining Shale Content of Sand

Some of the sands found in Minnesota contain shale to such an extent that they are unsuitable for use in concrete work. A simple field test to determine the percentage of shale, which has proved so successful that it will be of help in other locations when the available fine aggregate contains particles of shale is described in Concrete Highway Magazine.

Equipment for Making the Test.

The principle employed is similar to that used by the gold miner. The pans and the process of elimination are very much like the old "gold panning" method. Sand settles on the bottom of the pan while shale, being lighter than sand, will readily float to the top. A small amount of agitation under water will separate the materials. The proportion of shale in the sample can then be estimated. Sands having more than 1 per cent of shale are considered unsuitable for use in concrete.

The test is made as follows: An average sample of sand is selected and placed in a small pan. This is then immersed in a larger pan filled with water. As soon as the sample has become thoroughly saturated it is shaken along a horizontal plane, the small pan being kept slightly under water. The shaking should be done with short, quick strokes to give the water a chance to work through the sand while it is being agitated.

When the shale begins to appear on the surface of the sand, the small pan is lifted from the water, leaving about as much water in the pan as will equal the volume of the sample. The shaking is continued as before, but the pan is now tilted at an angle of 30 degrees. The shale collects at the top of the sand and at the point where the water backs up on the bottom of the pan. The relative quantities of shale and sand can then be readily estimated. After a few trials it is an easy matter to bring the shale to the surface.

The equipment necessary for this test is simple and inexpensive. One large pan about 6 in. deep and 15 in. in diameter and a smaller pan about 1 in. deep and 8 to 10 in. in diameter with flaring sides and rounded edges are all that is required.

Considerations for a Road Policy for Canada

Paper Presented September 7 Before the General Professional Meeting of the Engineering Institute of Canada

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The roads and highways of any country hold a very unique position. They are entirely devoted to, and can be considered only from, the viewpoint of "service." There is no other reason why there should be roads except to serve the public. Railways serve the public, but up to the present they have not been constructed to serve unless there is a hope that they will at least pay their way. Street railways, power systems, telephone systems, waterworks and other public utilities are expected to be paid for directly by those who enjoy these utilities; but roads are to be paid for by the public at large and seldom if ever by the people who use them in proportion to services received. In considering a road policy we must always keep before us that the whole aim of our policy must be one which will give the greatest value in service. This service is not for any one group of people—not for the farmer alone or for the manufacturer; not for the man with a team or the man with the automobile; not for the worker alone or the pleasure seeker; but service to all who wish to use the road.

Importance of the Road Question.—Before giving consideration to some underlying principles in selecting a road policy it may be well to bring out some facts which will emphasize the importance of the road question, and in so doing it will be compared with that utility with which it can best be compared, the railway. Looking up the railway statistics for the year 1919, we see that in that year the railways carried 111,487,780 tons of freight, which cost the owners 273 million dollars in freight charges. The Dominion Commissioner of Highways has estimated that about 50 per cent of this freight was at one time or another hauled over rural roads, and an analysis of the type of freight which made up this tonnage would bear out this estimate. It must also be kept in mind that there is a large amount of material moved over rural roads which does not reach the railways. It would therefore appear that this estimate is on the low side. The commissioner also estimates that the average length of haul on rural roads was 7.6 miles and the average cost of hauling at least 35 ct. per ton-mile. Allowing 56 million tons moved, we find that the cost of hauling this material on roads was about 149 million dollars or about 54 per cent of what was spent for freight on the railways. In 1919 the railways carried 48 million passengers at a cost of 96 million dollars and making about 3.6 billion passenger-miles. We have no records of passengers travel on roads and can only estimate again, but we know that in 1921 there were 463,848 automobiles registered in Canada. Allowing an average of two persons per car and that each car traveled 5,000 miles per year we find that automobiles made 4.6 billion passenger-miles, a considerably greater passenger-mileage than the railways. Allowing 10 ct. per automobile-mile, we find that the cost of moving passengers on roads was about 232 million dollars, which is greatly in excess of money spent on railway passenger travel. This does not take into account traffic by other vehicles on roads. These figures, while only estimates, show two things—first, that the subject of roads is important enough to warrant a careful study for, and the putting into effect of, a comprehensive road policy; and second, that the amount of service rendered to the public by roads is as great, if not greater, than that rendered by the railways.

Up to the end of 1919 we find the capital invested in railways in Canada to be over two billion dollars. To this must be added the capital expenditure of over 413 million on government railways and nearly 24 million on provincial railways, making a total capital of about two and one-half billion dollars. The Dominion Government aided other than government railways to the extent of nearly 222 million dollars; the provinces over 43 million and municipalities over 16 million. They have had land grants of over 44 million acres and bonds guaranteed to the amount of 344 million dollars. These figures show the value which the public of Canada has placed on this utility which performs a service similar to that performed by the roads, but whose utility and investment would be of no value without the service given by the roads. While the railways perform a service, this service is paid for by the users of the railways and the utility is expected to pay at least interest on the money invested therein. Roads have no opportunity to show a balance sheet and must therefore depend entirely on service for justification of their construction.

Divisions Under Which a Road Policy Should Be Considered.—The consideration of a road policy falls into two divisions: 1st, executive; 2nd, financial. Under "executive," we must first consider who will have charge of the roads. Will they be constructed and operated privately or by public bodies. This question has already been answered for us and it seldom enters our mind that they could possibly be operated by private corporations in competition with each other, although if they were operated in some such way our highway system would be in much better shape than it is today. It has been determined for us that they are to be under the control of some public body. Of these there are in general three bodies, who are in a position to assume this duty; (1) the Federal Government, (2) the Provincial Government, (3) the Municipal Government. To put roads under control of the Federal would in some cases probably require changes to the British North America Act.

In a railway, where the haul is inter-provincial, it is essential that one central body should have control of a complete system. In roads it is not essential that there should be one central body in control throughout the Dominion. Freight hauls and passenger travel on roads, on the average, are over short distances as compared with the railways, and a large percentage of both of these originate and terminate within one province. There remain the other two bodies: the provincial and the municipal. The first means one central organization, the second means a large number of small organizations. In order to discuss which type of control would be better let us examine what is required of the road.

Types of Traffic.—As the purpose of the road is service, we must know to what type of traffic we are to render service and what it requires. It is evident that the road must be constructed to suit the traffic (within reasonable limits), instead of expecting the traffic to suit the road.

The first two divisions to be made are: (1) serving a well developed district and, (2) serving a new district. The traffic in the developed district will be outside or through traffic, and local traffic. The through or outside traffic will consist of strangers to the road and those more or less familiar with the road and will consist nearly all of motor traffic. The local traffic will consist largely of team-drawn loads with some, (and rapidly increasing), motor truck loads, automobile traffic (mostly of the district), and some light team traffic. The traffic to be served under the heading of "new districts" will be mostly local traffic consisting chiefly of team-drawn loads, and a very light motor traffic.

What service is required by the stranger to the road? If he is a stranger to our country he may be on a tour intending to cover a considerable distance, and will be interested in passing through the country from one city to another along main highways. The impressions which he retains of our country will depend on the enjoyment which he obtains from his trip. He probably will have a schedule laid out which he wishes to follow. To serve him the road must first of all be safe under all conditions. It must be well marked so that he may follow it at any time with certainty and ease of mind. It must be passable at any time during the traveling season. It must be a fairly direct route from city to city and must connect up with similar roads in adjoining provinces. Road laws must be the same throughout. A similar service is required by the man who is more or less familiar with the road. To this man, safety, directness and passable conditions of the road are most essential as he will undoubtedly be driving more at night than will the stranger; and in many cases a saving in time due to directness of route means actual dollars to him. In addition to the service required by the stranger he will require more highways, reaching more cities and towns. The roads to serve these two classes must be designed primarily for automobile traffic.

What service is required of the road for local traffic? The traffic will consist of team-drawn loads from farm to market, and from town to town; some truck loads mostly from town to town with a chance that there will develop a motor truck traffic from farm to market. There will be auto traffic from farm to town and from town to town partly for pleasure, partly for business. There will be light team traffic, school vans on some roads and some roads will be mail routes. For team-drawn loads the road surface should be passable in any sort of weather. It should be so that the cost of transporting the load is a minimum. It should be safe under all conditions; and should be direct. For truck loads it is even more important that the roads be passable at all times. Grades are not so important as for teams but directness of route is more important. Local auto traffic demands a road safe at all times but perhaps, is not so much concerned if the road should not be first class for a few days at a time. School vans demand that the roads be in good condition at all times during the school term and especially is a safe road required for this class of traffic. The postal routes must be safe and passable at all times.

Summing up for this division of traffic it appears: First, there are three classes of traffic and consequently three classes of roads; (1) "through" traffic requiring "through" roads; (2) town to town traffic; and (3) farm to market traffic. This latter including school van routes and probably postal routes. Summing up the service which each class of traffic requires we see that all require safety; mostly all require that the road be passable at all times; next directness of route; next light grades; and then a well marked route. To all these classes there should be added the pleasure seeker or the man who is out for recreation only and who desires to see the beauty spots of the country. He is interested only in roads which are safe and passable at all times and which run through the prettiest portions of the country.

The requirements in a district being opened are quite different from the older settled district. Auto traffic will be comparatively lighter and team-drawn vehicles will constitute the greater portion of traffic. The total volume of traffic will be light and speed not such an essential item. The road ditches in many cases must serve for draining the country. The service required by a road in this country is such as to justify a much cheaper type of road than in the older districts, but nevertheless it is a very important service which they must render.

So far we have considered roads from the viewpoint of the person who uses the road. We must also consider it from the view of the man who pays for the road. If he is a payer and not a user, in the majority of cases he does not want to spend any money on roads. If he is a payer as well as a user he wants the money spent in the manner to give the maximum value, and he wants to know where and how the money is spent.

Executive Requirements. — Having considered the service requirements of the different types of traffic, let us see what is required of the executive to provide this service—evidently a competent organization and money. To give the service required by those using the road the organization must consist of men who have knowledge of how to produce the results required, and the man who pays requires that the organization consist of men who can produce the results economically. To quote partly from the Commission of Highways for Canada, the organization must consist of "men who have had the training and experience to meet the problems which arise" and who "have been imbued with the public service idea and the necessity in the public interest of expecting one hundred cents in the dollar in value of workmanship and materials." This organization is expected to be capable of gathering engineering and economic data, correlating it, applying it, and filing it; of looking after the carrying out of construction; and as fully important, if not more so, of looking after maintenance; of seeing and knowing that work is properly done, money properly expended and that accounts and records are properly kept. To do this, the organization must have men of several types of training.

Some of the data to be gathered consist of facts about the amount and type of traffic which now uses the road; facts which will govern the change in volume and type of traffic which will use the road, when it has been improved, and in the future; facts regarding the cost of construction and maintenance of different types of road, the amount and kind of service which they will render under different traffic conditions; engineering data which will enable him to design the proper type of road and bridges to render the service required; facts regarding the costs of construction and maintenance; facts regarding the different methods of carrying out work and the use of different machinery and materials. The gathering of this data requires a man with a certain sort of training. The keeping of accounts requires another type of training. Men are required with office training for detail office work. The organization of the staff and keeping it running requires a certain type of training, as well as the man who has the general direction of the carrying out of the policy and relating it to the public. Evidently, then, men of several different types of training are required for an efficient organization. To give the service which was stated as required by different types of traffic we know that safety requires a smooth, even surface, a proper cross-section, strong culverts and bridges, protection of high fills, and clear view, and for through roads, uniformity. To be passable at all times means generally some type of surfacing and the proper type of surfacing for the traffic. Both of these require immediate, constant and uniform maintenance.

Where Control Should Be Placed. — With control in one large central body an organization can be constructed of the men with the different types of training required to give the proper service. Continuous safe roads will be constructed, marked and maintained in a uniform manner. Proper machinery can be purchased in larger quantities and at opportune times. Gravel pits and stone quarries can be purchased for present and future use. Work can be planned and arrangements made for carrying it for some time ahead and in proper order. Authority and uniform laws can be authorized by legislation easier to one body than a great variety of laws to a large number of bodies. Arrangements for financing the work can be easier and better made. The cost of the work can be properly placed when it has once been decided how the costs shall be borne. On the other hand, the provincial organization offers a greater chance for manipulation of politicians. There is an opportunity in a large organization for a large waste of funds and for over organization. The members of the organization may not take as keen an interest in the work as might members of municipal organizations. Provincial government organizations are generally bound by fair wage schedules in having any work carried out.

Municipal organizations are free of control by provincial politicians. They are more intimately connected with the work and there is less chance of a squandering of funds. There is a probability of a keen interest being taken in the work on account of their intimacy therewith. They are not bound by fair wage schedules but free to obtain labor on an open market at competitive prices. They have intimate knowledge of the local requirements for roads. They can generally get work done cheaper by local labor in small portions than can the larger organizations. On the other hand, they cannot build up an organization of men with the different types of training required. Continuous and uniform roads will not be constructed; each municipality will construct roads according to its idea, often with no regard to continuity and sometimes each councillor will construct his own peculiar type of road in his own ward. One municipality will have safe roads and the next very poor roads. Proper machinery for construction and maintenance cannot always be purchased. Large gravel pits for future use will not likely be reserved. Materials cannot be purchased at such an advantage. Roads will not be as uniformly marked. Raising of money will be more difficult and allotting of costs cannot be so fairly done. Records will not be so well kept.

These are some of the things to be considered in deciding how the roads are to be controlled. There are also several forms of dual control which might be considered. The province to have control of some roads and the municipalities of others. The control might be under the municipality subject to certain control and approval by the province, or vice versa; and all shades and varieties of these dual controls. It would be only under ideal conditions that dual control would work out satisfactorily. After the decision as to who shall have control comes the selection of the organization. Considerable space might be devoted to consideration of this. Once the organization is properly formed, a big step towards the success of the road policy has been taken. After this comes the method of construction. The selection of the type of roads and construction is a matter of engineering detail and once the right organization with sufficient authority has been formed, these can be satisfactorily worked out.

Financing of Roads.—Coming to the financial question, this might be divided into three heads. (1) How much money should be spent yearly on roads; (2) how it is to be raised; (3) on what basis will the cost be distributed. The answer to the first question is beyond the knowledge of the writer, but it appears that by a proper study of wealth produced in this country, and from a study of value which might be received from good roads, that the maximum and minimum amount which should be spent on roads could be arrived at. This appears to me to be an immense question in itself, involving not only a study of present value which would be received, but also of future benefits which might accrue. This last includes a study of our material resources, probably methods of development as related to roads, and a study and plan of the whole future development of our country. This opens to us a vision of what the road question means when considered in its wide aspects.

The second question has been answered in many ways in different provinces and countries. The money must be raised either, (1) current revenue; (2) term debentures; (3) capital account; (4) a combination of any two or more of these methods. The selection of which method should be used is a study in itself and should be decided by men of training in financial matters who are familiar with the various factors that determine which method should be adopted. The method that would be satisfactory in one section of the country might not be satisfactory in another. If members of a community had the opportunity to loan money in small sums at a higher rate of interest than they could borrow in large sums, it might be better to borrow money for roads. This might be the case in one community and not in another. If money can be borrowed at a time when one bushel of wheat will pay off a dollar, it might be of advantage to borrow. In a new district it might pay to borrow money to improve the roads and open up the country for settlement and the increase in wealth produced might repay several times over the money required to pay back the debt. No attempt will be made here to solve this question but merely point out that the road question is not one of simply pushing up earth with a push grader, but is one requiring the services of men of a variety of training and experience.

The third question, "On what basis will the cost be distributed?" offers another field for considerable study in order to arrive at an equitable solution. In most public utilities those using the utility bear the cost; but others besides those using the roads receive benefits. The land owner who has a good road constructed by his land is receiving benefits from the road even if he lives miles away, his farm not under cultivation, and the road never used by him. It seems reasonable that he should share some of the cost of the improvement, and that the whole cost should not be carried by those using the road. If a good road tends to reduce the cost of marketing produce or enables the gardener to get his produce to the consumer in a fresher state surely the consumer is securing some benefits. If a good road enables children to get to school where otherwise they could not, who can place the benefits which may be received from the results of the education of a child which may become the leader in our country.

The first consideration which comes to mind is, should the money be raised and the cost assessed by federal, provincial or municipal governments? It is not clear to my mind why the Dominion government should undertake the financing of road building. The people must pay and they pay no less by paying it through the Dominion organization rather than some other. The sources of Dominion revenue are not directly connected with roads and the public services which are under Dominion control are not directly interested in roads except the postal and military services, so that the raising of money by the federal government appears to have no direct connection with road service nor is the money likely to be spent on roads which directly affect federal services. However, those who are interested in this phase of road financing can undoubtedly supply adequate reasons why the federal government should assist in financing road construction. On the other hand, the provincial governments obtain revenue from sources which receive service from roads, such sources as automobile license fees, direct taxes on land values, direct taxes from those who haul loads over the roads. The municipal source of revenue includes direct taxes on land values and on those who are the main users of roads. It would appear to the writer that the financing of road construction should be a function of the provincial and municipal governments.

As the money must be provided by the individual, in the final analysis we must give consideration as to how the cost is to be distributed to the individuals. This might be done on the basis of ability to pay or on the basis of benefits received. While taxation on the basis of ability to pay might be a fair basis for certain government services, it does not appear to be equitable that this should be the only basis on which to secure revenue for road construction. In general, public utilities rendering similar service are paid for on the basis of service received and this appears a fair basis for obtaining a greater portion of the revenues for road construction. Its equitable application is difficult if not impossible. Those receiving most of the direct services are the users of automobiles, motor trucks, farm teams, other team loads, light teams, school vans and mail routes. The majority of automobiles and motor trucks do most of their traveling on certain main highways and town to town roads, but they do some traveling on other roads; farm teams do most of their hauling on market roads but they do some on main highways and town to town roads; the land owner, we saw, received some value; the consumer of products receives some value; and the people at large receive some value. The question is in what proportion do they receive value from good roads. We assumed that the average motorist traveled 5,000 miles per year at a cost of 10 ct. per mile. If the good road reduced the cost only 10 per cent it would be worth $50 per year to him; but this is away low in the saving which will be effected. In the first place you cannot run a car on poor roads for less than 15 ct. per mile; secondly, the saving will be much in excess of ten per cent in the cost of running the car, and thirdly, a saving of still greater value will be made in the saving of the time of the passengers. If automobiles were taxed $50 per year and this money put into proper roads they would, on the average, still be money in pocket. With half this money we would have a yearly road fund of over 11 million dollars from this source alone. We estimated that 56 million tons of freight were hauled over rural roads at a cost of 35 cts. per ton-mile. If the cost were reduced to even 30 cts. per ton-mile we would effect a saving of over 6 million dollars yearly. The average value of farm land in Canada is estimated at $48 per acre. Suppose good roads were established and the value of land increased by $5 per acre, the interest on this at 6 per cent is 30 cts. per year or about 6 mills per acre. Suppose we ask only one-half this value to put into roads or 3 mills. The estimated value of farms and farm buildings in Canada is over 4 billion dollars. A rate of 3 mills would give another 12 million dollars yearly. If we asked each poll to contribute 10 or 15 cts. per year for general value received we would add another million to our revenue, making a total yearly revenue of about 30 million dollars. We pay the railways directly over 369 million dollars per year. The point to be brought out is that there are several classes of beneficiaries from good roads; that consideration must be given to arrive at an equitable distribution of costs, mostly on the basis of benefits received; and that when these costs are distributed on this basis each person will be paying only a portion towards the value which he will receive.

It has been possible in this paper to point out only some facts which must be considered in deciding on a road policy. The main things which should be brought out are:

(1) That Service is the first consideration in a road policy.

(2) That the road problem is a large one and worthy of consideration by able men.

(3) That men of a variety of training, of broad experience and sound judgment should be requested to give their assistance in solving the problem of what should be a proper road policy for a country.

1923 State Highway Program in Montana

The State Highway Commission of Montana is at present engaged in completing surveys and plans for Federal Aid projects proposed for 1923 construction, involving 255 miles of graded and gravel surfaced road and 16 bridges over 20 ft. span. The 1923 work involves over 1,640,850 cu. yd. of common excavation, 118,800 cu. yd. of rock excavation and 388,000 cu. yd. crushed general surfacing and 744 pipe culverts.

These projects will be advertised for bids during the late fall and winter when the ground will probably be covered with snow. In order to give contractors an opportunity for a field inspection of the proposed improvement during favorable weather this fall and before plans, specifications and estimates are complete, the department will furnish all interested contractors, upon request, sketch maps or preliminary plans and such other data or information as may be available at the time fixed for the inspection.

Annual Costs of Highways In a Florida County

An interesting comparison of the annual costs of various types of highway surface under conditions obtaining in Duval County, Florida, was given by Mr. Geo. B. Hill, County Engineer, in a report submitted recently to the County Commissioners. Mr. Hill's investigation covered the following types of highway surfaces; and his estimates were based on the unit of 1 mile of road 16 ft. in width involving 9,387 sq. yd. of road surface.

"(a) Plain shell.

"(b) Shell treated with Bindex, Dustex, or similar sulphide liquids.

"(c) Augusta gravel, similarly treated.

"(d) Ocala limestone, with bituminous surface treatment.

"(e) Bituminous penetration, on a limestone base.

"(f) Sheet asphalt with binder course, on limestone base.

"(g) Vitrified brick with bituminous joints on sand base.

"(h) Vitrified brick with bituminous joints on limestone base."

We quote from the report as follows:

The estimates of annual maintainance costs for various pavement types presented hereafter are based on effective and efficient maintainance by patrol. Without the provision of such maintainance, the figures are of little or no value; and the question of highway costs over a period of years becomes purely speculative. Such estimates are also based on an amount for each type. Should the density of traffic exceed such limits, the resulting increase of maintainance cost would call for replacement by a heavier type of road. It should be noted that the following figures cover surface and foundation only, and do not include grading, or drainage and ditching.

It should also be noted that in the preparation of the following estimates we have not included any amount to cover interest on the investment. The inclusion of such an item would effect a greater proportionate increase in the annual cost of the heavier or more permanent roads, due to their greater first cost. This intentional omission is, however, in our opinion, offset by the fact that such roads have a considerable residual value at the end of their life as estimated herein, while the lighter types of road have little if any. No figure has been placed on such residual value herein in determining average annual cost.

Plain Shell.—Oyster or periwinkle shell costs approximately $2.50 per cubic yard spread in place but not rolled on the average road in this county. The use of shell provides a road satisfactory for light horse-drawn traffic, but under the vacuum action of high speed rubber-tired automobiles such roads fail rapidly. They are dusty in dry weather and wash badly under rain. They are expensive to maintain and the best that can be said for them is that their first cost is low and that they are better than a road of sand.

Six inches of loose shell will compact to a thickness of about 3 in. Under traffic not to exceed 300 vehicles per day such a road will require entire replacement at the end of two years.

The estimated cost follows:

Initial cost, 6 in. loose shell, 1,565 cu. yd. at $2.50	$3,912.50
Maintenance, two years at $400 per mile per year	800.00
Total cost in two years, per mile	$4,712.50
Average cost per mile per year	$2,356.25

At the end of two years, the original surface will have no residual value.

Shell Treated with Bindex.—The treatment of shell roads with Bindex or some similar residual liquor from paper manufacture, of which there are several on the market, prevents dust, and provides some binding effect, and to that extent it reduces wear. A price of 13 ct. per gallon f. o. b. Jacksonville, is used herein. For best results the road should receive an initial treatment of 1 gal. of Bindex per square yard, provided in three treatments of ½ gal, ¼ gal. and ¼ gal. respectively. Thereafter, the road should receive an application of ⅛ gal. per square yard at intervals of four months. By such treatment it is believed that the life of 3 in. of compacted shell would extend over a period of five years, requiring complete replacement at the end of that time, if subjected to traffic not exceeding 300 to 350 vehicles per day:

The estimated cost follows:

Initial cost, 6 in. loose shell, 1,565 cu. yd. at $2.50	$3,912.50
Initial treatment, 9,387 sq. yd. at 19c	1,783.50
Maintaining treatments, 9,387 sq. yd. at 7c per year for five years	3,520.20
Scraping and dragging, $100 per mile for five years	500.00
Total cost in five years, per mile	$9,718.30
Average cost per mile per year	$1,943.24

At the end of five years the original surface will have no residual value.

Augusta Gravel.—Augusta gravel is a mixture of gravel, sand and clay with some kaolinic content. A considerable mileage of roads have been built with it in Georgia, but the federal road department indicates that its value untreated is limited to roads carrying relatively light traffic. Treatment with some product similar to Bindex would doubtlessly increase the life and reduce the maintainance costs of roads constructed of such material.

Augusta gravel is quoted at $1.52 per ton f. o. b. Jacksonville. It averages 2,700 lbs. per cubic yard in weight, and 9 in. loose will compact to 6 in. thickness. Allowing $3.20 per cubic yard in place, the estimated cost of a mile of road 6 in. in compacted thickness, is $7,510. It is estimated that under traffic not to exceed 450 to 500 vehicles per day, such a road would require replacement at the end of ten years.

The estimated cost follows:

Initial cost, 6 in. compact gravel	$7,510.40
Initial treatment	1,783.50
Maintaining treatments, 9,387 sq yd. at 7c per year for ten years	7,040.40
Scraping and dragging, $100 per mile for ten years	1,000.00
Total cost in ten years	$17,334.30
Average cost per mile per year	$ 1,733.43

At the end of a 10-year period there should be considerable material left which would be of value as foundation for reconstruction. Gravel is not, however, satisfactory for covering with bituminous top, as there is a tendency for it to peel off. An intermediate layer of limestone would be required to permit its use as foundation for such construction.

Limestone, Surface Treated.—A limestone, commonly designated as "Ocala" limestone, is mined in several quarries in this state. It has excellent value as a foundation material, due to its cement qualities and to its elasticity. Excellent roads have been built in various parts of this state through the use of this material as a base, and with a bituminous mat surface. Six inches compacted thickness of this material will provide a satisfactory foundation for any ordinary main line highway in this county, and we would recommend the laying of that thickness in surface-treated roads, as it would be available as foundation whenever a more durable surface was required.

This material costs approximately $2 per cubic yard f. o. b. Duval County, and on that basis a mile of 16-ft. pavement 6 in. in compressed thickness, will cost $6,264.

Surface treatment will require the initial application of approximately ¼ gal. of Tarvia B and ⅓ gal. of Tarvia A, or of asphalts of equal consistency, followed by an application of 30 lb. of well rolled slag or granite chips per square yard of road surface. Such surface treatment could be done by county forces at a cost not to exceed 25 ct. per square yard, based on the purchase of bitumen in barrels and on hand pouring. By the investment of approximately $12,000 in the purchase of storage tanks, sweeper, and pressure distributor, the cost could be reduced to 21 ct. per square yard, and the county further would be in a position to insure proper maintenance and a continuous program of new construction.

Maintenance of surface treated lime rock roads equivalent to the provision of a complete new surface each three years should be ample to secure a life of twenty years under traffic up to 750 or 800 vehicles per day, and at the end of that period the original base should be entirely available as foundation for a new surface. In the following estimates, the price of 25 ct. per square yard for surface treatment is employed.

Initial cost, 6 in. compacted limestone	$6,264.00
Initial treatment, 9,387 sq. yd. at 25 ct.	2,345.75
Maintenance 8 ct per sq. yd. per year for 20 years	15,019.20
Total cost in 20 years	$23,629.95
Average cost per mile per year	1,181.50

At the end of a 20-year period the original limestone base should be practically all available.

2½-in. Bituminous Penetration.—This type of road similar to that recently constructed on Edgewood avenue and Kings Road, is generally considered as a permanent type of construction. With proper maintenance it should have a life of 25 years under traffic up to 1,500 vehicles per day. Our estimates contemplate construction of a surface 2½ in. in finished thickness, using slag or granite or aggregate and tar or asphalt as bitumen, laid on a base of 6 in. of compact limestone, and provided with concrete curbs flush with the ground surface. Maintenance by patrol system should not exceed 4 ct. per square yard or $375.48 per mile per year.

This is a type of road that could be built by the county with its present equipment, and with greater facility and less cost if the equipment previously mentioned were available.

The estimated cost follows:

Initial cost, 6 in. compacted limestone base	$ 6,264.00
Initial cost, 2½ in. bituminous top at $1.20 per sq. yd.	11,264.00

Initial cost, concrete curb ...	2,500.00
Maintenance, 4 ct per sq. yd. per year, for 25 years..	9.837.00
Total cost for 25 years........	$29.865.00
Average cost per mile per year .	1,194.60

Sheet Asphalt Surface with Binder Course. This type of pavement, consisting of a sheet asphalt surface 1½ in. in thickness, laid on a close binder course 1½ in. in thickness, all supported by a 6-in. compact limestone base, is a high grade permanent surface. It requires special, expensive plant for its construction, as the surface and binder courses are built of material mixed together in a machine while hot, and thereafter spread and rolled. A concrete curb should be provided for this type of construction. Such a pavement will handle any traffic to which the roads of this country may reasonably be subjected, and with a proper system of maintenance, the maintenance cost should not exceed $350 per mile per year for a 30-year period.

The estimated cost follows:

Initial cost, 6-in. compact limestone base	$ 6,264.00
Bituminous top and binder course at $1.50 per sq. yd.............	14,080 50
Concrete curb	2,500.00
Maintenance, $350 per mile per year for 30 years	10,500.00
Total cost in 30 years	$33,344.50
Average cost per mile per year..	$ 1,111.48

At the end of 30 years the limestone base should be fully available, and the bituminous top will have value for use as binder course in future work.

Vertical Fiber Brick; Bituminous Joints; Sand Base.—This type of construction will provide a road that will handle satisfactorily traffic of medium density, up to 650 or 700 vehicles per day. A concrete curb is required.

The estimated cost follows:

Initial cost, brick surface at $2.90 per sq. yd.	$27,222.30
Initial course, concrete curb ..	2,500.00
Maintenance, 25 years at $500 per mile per year	12,500.00
Total cost for 25 years	$42,222.30
Average cost per mile per year..	$ 1,688.89

At the end of a 25-year period, the brick should have some relay value.

Vertical Fiber Brick; Bituminous Filler; 3-in. Compact Limestone Base. This is a first-class permanent pavement and should carry any traffic reasonably to be expected on the roads of this county. With proper maintenance, the upkeep should not exceed $250 per mile for a 30-year period. This type of road could be built by county forces, but it is believed that better results would be secured by having work done under the direction of a contractor of experience and reliability.

The estimated cost follows:

Initial cost, 3-in. compact limestone base	$ 3.132.00
Initial cost, brick surface at $2.90 per sq. yd.	27,222.30
Initial cost, concrete curb	2,500.00
Maintenance, $250 per mile per year for 30 years	7.500.00
Total cost for 30 years	$40.354.00
Average cost per mile per year..	$ 1.345.14

At the end of a 30-year period the brick should have considerable relay value and the limestone should be fully available.

Summary of Costs.—Table 1 presents a resume of the figures given in the report. All figures are based on a unit of one mile of road 16 ft. in width.

Table 1—Capacity, initial cost, life, annual cost and residual value of various types of road surfaces:

TABLE 1.—CAPACITY, INITIAL COST, LIFE, ANNUAL COST AND RESIDUAL VALUE OF VARIOUS TYPES OF ROAD SURFACES.

Type of Road..	Capacity in vehicles per day.	Initial cost per mile.	Annual maintenance per mile.	Estimated life—years.	Average annual cost per mile.	Residual value.
Plain shell	300	$ 3,912.50	$400.00	2	$2,356.25	None
Shell and bindex	300-350	5,696.00	788.59	5	1,943.24	None
Augusta gravel and bindex...	450-500	9,293.90	788.59	10	1,733.43	Small
Limestone, surface treated ..	750-800	8,610.75	786.96	20	1,181.50	$6,000.00
Bituminous penetration	1,500	20,028.00	393.48	25	1,194.60	7,500.00
Sheet asphalt	3,000	22,844.50	350.00	30	1,111.48	9,000.00
Brick on sand, bit. joints.....	650-700	29,722.30	500.00	25	1,688.89	2,500.00
Brick on limestone, bit. joints.	3,000	32,851.30	250.00	30	1,345.14	6,000.00

What Does a City Manager Do?

This question is well answered in the recently issued annual report of Harrison G. Otis, City Manager of Clarksburg, W. Va. The report covers the first complete fiscal year of the Council-Manager Government in that city.

The accompanying chart reproduced from the report shows the organization of the city government, and the following notes reprinted from the report indicate some of the duties of the city manager:

In addition to acting as presiding officer of the council, chairman of the board of revision of assessments and serving on the sinking fund commission, the manager is charged by the charter with:

1. Supervising and directing all administrative offices and departments, except the police department;

2. Appointing of all administrative officers and other employees, except those of the police department;

3. Enforcing the terms of all franchises in favor of the city;

4. Recommending to the council measures and resolutions for adoption;

5. Acting as budget commissioner and keeping the council fully advised on the financial condition and needs of the city;

6. Determining the program of street improvements and deciding upon the kind and character of pavements, sidewalks and sewers;

7. Employing competent experts to advise in planning public improvements subject to the approval of the city council;

8. Signing all ordinances, resolutions and minutes of the council and executing all contracts, deeds and agreements authorized by the council;

9. Acting as purchasing agent for all departments;

10. Having prepared assessment reports for all public improvements to be paid for by abutting property owners;

11. Exercising any powers and carrying out any other duties authorized by the council or by the laws of the state.

Departmental Report System.—A system of detailed department reports involving the use of cards of uniform size, five by eight inches, printed by means of a duplicator, was instituted during the year and keeps accurate record of all activities. In most cases large daily report sheets are used by the departments, the total being transferred at the end of the month to the report submitted to the manager.

Conferences are held almost daily with the several administrative officers, yet each officer is given a wide range of authority within his department and is held responsible for the results. The manager never, except in emergency cases, deals with the employees in any department except through the head of the department.

Non-Partisan Appointments. — The charter names the several administrative officers and assigns their appointment to the manager by and with the advice and consent of the city council. No prospective appointee has

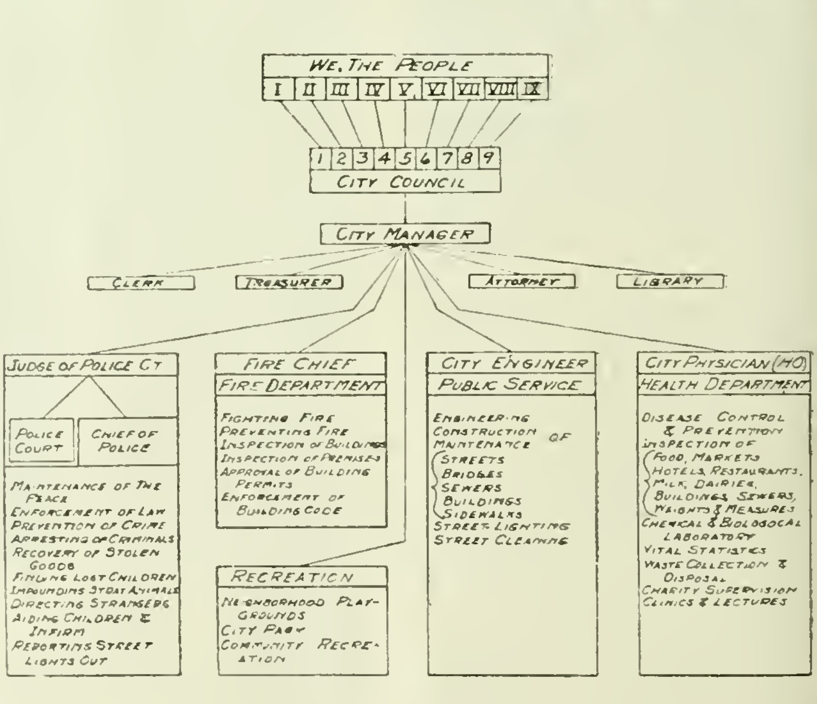


Chart of Council-Manager Form of City Government of Clarksburg, W. Va.

ever been asked as to his political or religious preferences, and a recent casual investigation developed that of 12 city employees receiving salaries of over $150 a month, six are registered as favoring one of the national parties, five favoring another and the twelfth man classed independent.

Itemized Budget Prepared. — An itemized budget requiring eight sheets of legal size paper typewritten single space, and showing corresponding figures for the previous year in parallel columns, has been drafted. This required a careful audit and reclassification of accounts of the last year under the old charter.

Such a budget aids the council in determining the levy and serves as a guide to expenses during the year.

Purchasing Centralized. — All purchasing has been centralized in the city manager's office. Department heads make requisitions on the manager, who places the order after ascertaining where the goods or services may be secured to the best advantage of the city. Standard forms for requisitions, quotations and orders are in use. Many commodities are being bought on a lower basis since this system was installed, with a consequent saving.

Sociological Aspects of Highway Transportation

Address Presented Oct. 27 at Conference on Education for Highway Engineering and Highway Transport

By C. J. GALPIN.

Division of Farm Population and Rural Life, U. S. Department of Agriculture.

There are two situations in America worthy the attention and serious consideration of all persons who are charged with the responsibility of planning our highways. I will forego, for lack of time, a discussion of the more general social and humanistic phases of our subject, and base my claim that sociology is a party to highway construction, on these two situations as types.

The first situation—and the better known of the two—is the congestion of people being born, living and dying in the residence quarters of most American cities. The second situation—no less acute and no less freighted with far-reaching results, although as yet only dimly recognized by the public in general—is the inaccessibility, taken by and large, of the American farm population, to modern facilities for trade, professional service, hospitals, schools, amusements and churches. Let us look a little more closely into these two situations.

De-Housing and De-Homing City Blocks.—In 1920 America had 68 cities, each with a residing population of from 100,000 to over 5,000,000, with a total population of 27,429,326. One hundred years ago one city in America reached a population of 100,000 persons. Fifty years ago only 14 cities came up to 100,000 persons each. America has at present 219 cities with a resident population of from 25,000 to 100,000 each, with a total population of 10,340,788; 459 cities, from 10,000 to 25,000; 721 cities, from 5,000 to 10,000. The congestion of resident city population concerns especially the 287 cities with a range of population from 25,000 up to 5,000,000.

It has been evident to sociologists and humanitarians for many years that national well-being suffers from urban residential congestion, by reason of the restricted floor space of urban land in residence areas. Child life and home life are the immediate victims of this congestion. It is difficult to draw a picture which exaggerates the physical, psychic and social penalties exacted upon a congested population.

One antidote for this urban congestion is the well-known suburban movement. The benefits of country homes are possessed now by a few fortunate people who do their work in city blocks, but go home to live in space and quiet in the country. The highway engineer is needed sorely at this moment—the engineer with daring imagination, to help scatter the dwelling houses and residence facilities of every one of these 287 cities far and wide into the outlying open country and thus in some appreciable degree to de-house, de-home and de-residence our congested American cities. Automotive traffic in city streets is driving into our consciousness day by day the crime of rearing and housing our race in business areas, manufacturing districts, and the crowded streets of motor transport in our American cities. A larger factor in decentralizing city homes is the transportation problem; and greater hope now arises in the humanitarian heart than ever before as one sees the new transport uses of the American highway. I would like to challenge the genius of highway engineers to help change this urban situation in the interest of the American home.

Making Living Facilities Accessible to Farmers.—In 1920, America had living on farms a population of 31,614,269 persons, young and old. This is almost 30 per cent of the total population of the United States—slightly less than one-third, and a little less than the total number of persons living in cities of from 25,000 up to 5,000,000. Rural sociologists pretty generally agree that our farm population is tremendously handicapped in the struggle for social equality with people of other occupations in respect to its living conditions—not to mention its economic difficulties—by reason of its present comparative inaccessibility to the modern social facilities and advantages of life. I invite your attention to this situation for a moment, because it is not as simple as one might suppose.

The fact is that the problem of this inaccessibility of farm homes to the commodities and skilled services and institutions of our modern age, is not simply a matter of waiting until farmers or some other body of people can afford to improve all the rural highways. It is far more complex than that problem, difficult as that may be. Rural sociologists are pointing out that the farm population of thirty odd millions is being brought into immediate contact with the best commodities of the world and the best thought of the world, through the agency of country stores, small groups of inefficient hamlets and villages, and totally inadequate local institutions—in the main through no fault of the farmer himself. Whereas the thirty odd millions of people living in cities of 25,000 population and over, are being brought into immediate contact with the commodities, skills and thought of the world, through the agency of all the devices and facilities which the ingenuity of the age has created.

The matter turns into a huge transport problem. How to get the commodities of living; how to bring the skills of service; how to mobilize the institutional wisdom of the world—from the world at large—and bring it to such evenly distributed rail and water terminals, that through an adequate highway system, a certain group of the farm population may find collected most of the things they desire at one of these terminals. In brief, this farm population situation calls for a system of adequate, complete terminal towns, connected by rail and water to wholesaling cities. These terminal towns—ranging in population from 1,500 to 5,000 souls, each connected by an adequate highway system to a group of farm population ranging from 2,000 to 7,000 souls respectively, would take the curse off from farming, and, in the words of Theodore Roosevelt, "Open the door to a good kind of life on the farm."

Highway engineers should know this social situation of the farmer, not only in order to help solve it, but also in order not to unwittingly block the coming of a new day for the farm by fastening a highway system upon the farm, which will chain the farmer to frontier facilities for another generation.

America already has 1,320 terminal towns of from 2,500 to 5,000 population. These, for the most part, stand ready to fall into a system of complete, efficient railway terminals.

Conclusion.—It is not our intention to make a proposal looking forward to the expenditures of vast sums of money at this time of agricultural stress and governmental retrenchment; but rather to ask that in the construction of better roads—of the county, state and national highway type—the social welfare of the common people be not only overlooked, but quite positively reckoned with. Granted that a large task has been stated; but also let it be granted that it looks ahead 100 years. It is the daring plan that is the thing. It is the bold idea that is needed, wrought into the highway thinking of the nation through its highway engineers.

Co-operation Between Engineer and Contractor

***Paper Read Before a Meeting of the Southern District of the Asphalt Association, Atlanta, Ga.**

By W. R. NEEL,

State Highway Engineer of Georgia.

This is a subject very often under discussion by all of the parties concerned. The engineer has his interpretation of the word co-operation, the contractor his and the owner his; but isn't it a fact that each one's idea about just what this word means is a little different?

Most specifications frankly place upon the engineer all of the decisions in the carrying out of a contract. It is my belief, however, that the engineer has, generaly speaking, fully realized that this authority is not given him to abuse. Fairness to both the owner and the contractor should be the goal which the engineer strives for.

My experience in life has been that almost everyone wishes to be fair according to his own lights—but I must admit that I have met some people with very dim lights. My experience has also led me to believe that, generally, misunderstandings are brought about by the ignorance of someone connected with the undertaking.

Frequently contractors submit bids without either a thorough knowledge of the specifications or of the site where the work is to be executed. It is also a fact that frequently misunderstandings arise, due to the fact that the engineer is either unfamiliar with the terms of the contract and the specifications or that he is so inexperienced that he is not capable of properly interpreting same.

Fairness to Both Parties to the Contract.—The first lesson to be learned by the engineer is, that he is not only representing the owner, but that he is also representing the contractor. Fairness to these two parties is the engineer's job. First, it must be recognized that the owner or beneficiary should pay the full cost agreed upon for the improvement. The second, that the contractor effecting the improvement should receive a fair compensation for his efforts, insofar as the limitations of the contract will permit. It should be the desire of the engineer to so assist the contractor that after the proper execution of the work a maximum profit can be made. It should be the desire of the contractor to so perform his work that nothing, either in the spirit or the letter of the contract, remains to be done toward securing for the owner a satisfactory job. With both the engineer and the contractor entering into their work with this spirit, true co-operation may be expected.

The laws frequently prevent the very thing for which they are written. They frequently prevent the awarding of the contracts to the best bidder; frequently there are written upon the statute books maximum salaries to be paid engineers, thus preventing the state or county from securing the very best engineering service. Very often you find a resident engineer or a division engineer in charge of a great many construction jobs and clothed with full authority, who may or may not be competent and who frequently is paid less money than the foreman of the construction gang.

Engineers Should Receive Adequate Salaries.—Contractors are always on the lookout for good men and good men are always on the lookout for a means of bettering their positions in life; therefore, it is imperative not only from the interests of the owner, but, also from that of the contractor that adequate salaries be allowed in order to secure and hold competent, experienced engineers. Not only is this true of the engineer but it is also true of the contractor. A well equipped contractor receiving a fair compensation for his work, with an experienced engineer (and generally this means an engineer receiving a fair salary), in charge of the work means a smooth running, harmonious job where real co-operation and satisfactory results to the owner may be expected. On the contrary a poorly equipped contractor who has submitted a bid which will not allow of a first class job with a fair margin of profit means contentions, and either the slighting of the job or calling on the bondsman, and this always means delay and ultimately a poorly finished job and a dissatisfied public.

Unfortunately all engineers are not to be entrusted with the wide powers generally given the "engineer" by the specifications. There are in every profession what corresponds to the "shyster lawyers"—that is a man who lives by making trouble. Many men employing engineers think that trouble between the contractor and engineer is to be expected and unless there is some trouble that the engineer is not looking after the job properly or is "in with the contractor." With this before them there are engineers who are unscrupulous enough to make constant trouble for the contractors; the result is loss to all contractors working under them or excessively high prices for work. The only remedy for this, in my opinion, is for reputable contractors to investigate the engineer in charge of work and in case his reputation is not good to refuse to bid or work in his charge and to inform men who employ the engineer the reason for declining to bid. Bonding companies could be required by the contractors to furnish impartial information in regard to an engineer's standing or reputation.

Another cause of trouble is placing an inexperienced engineer in responsible charge of work. Owners will employ a graduate engineer just out of college. The man may be entirely sincere in his efforts but through lack of knowledge of actual construction conditions he may, by over emphasis of some unimportant point cause a loss or at least unnecessary trouble without bettering the job in the slightest.

The Lowest Bidder Question.—A phase of this subject which I consider a real serious one is the insistent bidding of contractors both poorly equipped and incompetent to perform a first class job, but who can get bond. This class of bidder is a constant menace to the other contractors as well as to the engineer's reputation. Of course, you know how difficult it is for a public official to reject the bid of this class of contractor. In selecting any other than the lowest bid, the public official is immediately accused of partiality and even of graft.

The inspectors and the resident engineer are supposed to be able to enforce the carrying out of the plans and specifications and secure the same result regardless of what class of contractor is doing the work. Yet, any one at all familiar with construction knows how utterly impossible this is. To obtain first class results experienced, well equipped contractors and competent, experienced engineers and these co-operating to the best interests of the owner are absolutely necessary. Now, how can this be accomplished? In my opinion, the only practical way is for the engineer to reject all work not coming jam up to the plans and specifications.

If this is plainly understood, the result will be that contractors who are not equipped either with machinery or experience will either be deterred from bidding or, very soon, driven out of the contracting business. In order to carry out this plan successfully and with every assurance of fairness, specifications must be plainly written and competent engineers and inspectors placed in charge of the work.

Fall Letting of Highway Contracts

A campaign for the early letting of highway contracts was conducted last year by the Associated General Contractors of America. In this special efforts were made to explain to state highway officials and others interested that the main idea behind the suggested plan was not necessarily to award contracts in the fall, but to award them well in advance of the construction season, and with a greater degree of continuity where possible. This principle was approved by a majority of the highway departments, and a great number of them awarded a considerable portion of their work between September and March. A recent news letter of the association summarizes the results of the campaign as follows:

To ascertain how the plan was working out the association communicated with all the state highway departments a short time ago and received reports from 32 or about 70 per cent. These reports showed that a majority of the states which followed the plan for early awards in their 1922 program were in favor of the plan and found it advantageous. There were, however, considerations which, in numerous instances, prevented its successful operation. These were:

1. The contractors' difficulty in financing, in those states where materials delivered could not be paid for.
2. The late date of approving appropriations and making necessary financial arrangements.
3. The lack of co-operation on the part of some of the contractors.

Relative to the first item, the contractors were able to go only a limited distance in storing the materials as a department was unable to make payment upon them until they were incorporated in the work.

Relative to the second item, many state projects depended upon financial arrangements with counties or road subdivisions, and these could not be consummated in time to award contracts in advance of the construction season.

Relative to the third item, some of the highway departments reported that the contractors were apparently delaying operations in search of better prices and labor rates, or did not, for other reasons, see fit to take advantage of early awards.

An analysis of the reports from the different state highway departments shows the following:

Nineteen states out of the 32 adopted a plan for their 1922 program; five on account of climatic conditions make their awards independent of seasons, and eight for various reasons did not adopt the plan.

The number of men given employment on account of the off-season work ranged from 100 to 5,000. The probable average appears to be in the neighborhood of about 800.

The number of men that could be employed if the system was carried out as far as possible was estimated at from 100 to 6,000. The probable average appears to be about 1,000.

Of the 19 states that awarded contracts in advance, 15 reported that the work had, under these contracts, reached a further stage of completion than under those awarded under the old system. Four reported that the projects were not advanced and no advantage had been realized.

Seven states reported good co-operation of the contractors, seven reported poor co-opration, and 18 did not mention the question.

Approval of the early award plan given by 17 states, while five considered it unnecessary on account of climatic conditions, and two were decidedly opposed to it.

Developments in Concrete Road Construction

Abstract of Paper Presented at Last Annual Convention of New Jersey Highway Association

By L. N. WHITCRAFT.

Field Engineer, Portland Cement Association.

During the season of 1921 the construction of concrete highways underwent radical changes. In brief, the more important of these and their general functions are as follows:

Centre Longitudinal Joint.—This feature divides the entire pavement slab longitudinally and permits of pouring the full slab width in one operation. The diversion of the pavement longitudinally increases its beam strength about four times and further precludes the possibility of longitudinal cracks.

Doweling of Transverse Joints.—The use of dowels adds additional reinforcement at the joints and holds the adjoining slabs in the same relative positions. Dowels should be especially effective at the corners of the slab which are naturally weaker than adjoining sections.

Inclusion of Heavy Mesh and Bar Reinforcements, in Either Single or Double Layers.—The advantages of the heavier steel reinforcement, within reasonable limits, should be obvious for the reason that it gives the pavement greater structural strength and greater resistance to sub-grade changes. To more successfully resist both factors it is used, when deemed desirable, in both top and bottom of the slab and in either mesh or bar design.

Laying of a Uniform Thickness of Slab.—The weakest point of support of a pavement is at the sides which are usually left unprotected and are subjected to as great a load as in any part of the pavement. It is to secure greater strength, or the same strength at the sides as at the centre that a uniform thickness of slab is designed.

Keeping Subgrade Free of Material.—This requirement, of necessity, leads to the central proportioning and loading plant and permits of and facilitates an accurate centralized unloading plant. The keeping of the subgrade free and clear from material stock permits of more accurate workmanship in the preparation thereof so that with no subsequent obstructions or disturbance the sub-grade should be found both true to grade and cross-section at the time of placing concrete.

At first thought these changes in design gave one the impression that we are getting beyond reasonable economic limits. Such, however, has not proved to be the case. On the other hand each and every feature has apparently well performed the function for which it was designed and without unduly increasing the cost of these highways.

Centre Longitudinal Joints.—The construction of the centre longitudinal joint and the finishing of the groove directly over same has been greatly simplified and perfected by the placing temporarily of a 2-in. metal cap upon 1-16-in. dividing sheet. This cap consists of two ⅛-in by 2 in. strips of iron and one 1 in. by ⅛-in. strip of 8 to 10 ft. lengths riveted together with the 1-in. strip between the 2-in. strips. With the metal dividing sheet placed upon the sub-grade and coming within 1 in. of the finished surface the placing of this cap upon same brings its top surface to finished grade. When properly staked this permits the placing of concrete and finishing over the full width of pavement. In addition thereto the metal cap so placed gives sufficient rigidity to insure the dividing sheet remaining in a true line and perpendicular to the sub-grade.

After final finishing of surface is accomplished and the concrete becomes sufficiently stiff to hold its shape the metal cap is removed. The edges of the groove so formed are then rounded with an edging tool of ½-in. radius and the groove is ready for pouring with tar or asphalt at any time after the concrete hardens and before the pavement is opened to traffic. Care should be taken, however, not to obtain a groove of greater than 1 in. opening across the top, reasons for which are obvious.

Doweling of transverse joints by the installation of iron rods is an easily accomplished construction feature. Nevertheless it should be carefully done in order that these rods shall be parallel to both the finished surface and the axis of the pavement. It is also very essential that one-half of the length of each rod is so protected by wrapping that there is no bond with the concrete. Also that a space for longitudinal slab movement is provided at the end thereof. Failure to properly provide for these features may cause a rupture or spalling.

Heavier Reinforcement Designs.—With respect to the use of the new designs in reinforcement far better construction results are to be had in the use of the bar or heavy mesh reinforcement than with the lighter types of mesh. This is due principally to the greater rigidity of the heavier reinforcement and the recently designed methods for accurately supporting same in place by the use of pipes laid upon the sub-grade. Where the double layer of reinforcement is used the accurate spacing apart of the mats is simplified by the use of "chairs," which are fabricated with the mats. Better yet, this can be accomplished by the inclusion of deformed or bent members in the makeup which serve as "spacers" and have a definite reinforcing value as well. These methods of supporting and spacing apart of the double layer of fabricated mats have one great advantage in that this so-called "cage" of completely fabricated double layer reinforcement permits of pouring the concrete in a single full course depth. This is also a distinct advantage over the old practice of placing a course of concrete then a layer of reinforcement by another course of concrete, especially when dry concrete is used.

Uniform thickness of slab requires no different construction than the pavements of greater thickness at the centre than at the sides, other than in the former sub-grade is shaped to the specified crown, which is usually 2 in. or less, while in the latter the sub-grade is flat. The impression prevails that the crowned sub-grade is preferable to the flat one principally because of the fact that it drains off and dries out more rapidly. This is a desirable feature in connection with progress and the preservation of good sub-grade conditions.

Handling Aggregate.—No one feature in the construction of concrete highways has been productive of more highly desirable results in character of workmanship and quality of these highways than that of keeping the aggregates off the sub-grade. As a result we now find anywhere from one to twenty batch units being delivered to the mixer all proportioned accurately alike which makes for greater uniformity of concrete. The properly prepared sub-grade, at all times unobstructed, should insure the required thickness of pavement at all points. With this requirement in effect one can readily tell whether or not the specified thickness of pavement is being placed. Another feature is the facility with which the sub-grade can be restored to its proper condition in case of disturbance by rains or other causes, such as the development of weak spots due to unsuitable subgrade material which it may be necessary to remove.

The thought prevails generally that heavily reinforced concrete pavements do not crack, and it has been with a view to eliminate cracks that the reinforcement feature has been given so much consideration. Admitting that this effort has met with a great measure of success, we must at the same time acknowledge that the results are not quite up to our expectations.

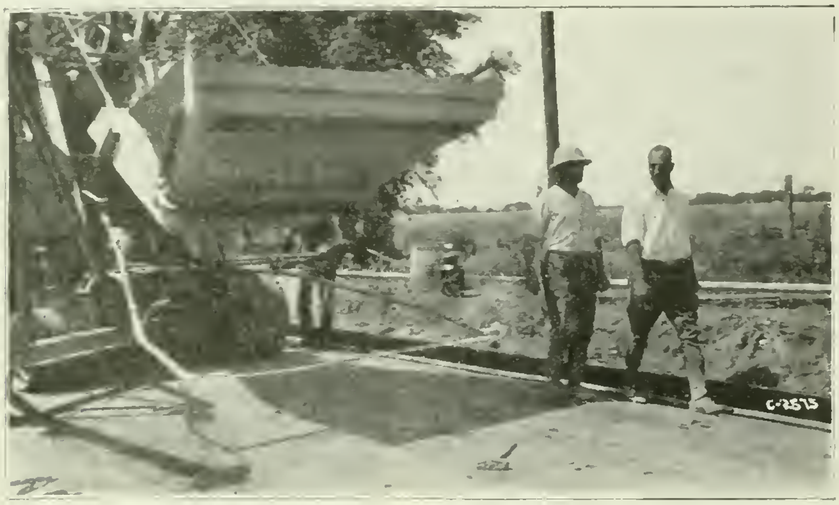
It is a generally accepted theory that cracks are due to frost action, changes in temperature and unequal bearing power of the sub-grade. Yet if these were the only causes the heavier designs of reinforcement would serve to more nearly eliminate them.

From an observation of the methods of construction of these pavements I am led to believe that the most successful and effective method of eliminating cracking is the use of reinforcement together with the proper protection and procuring of the concrete during the early hardening period. It is during this hardening period, when the concrete has little or no strength to resist shrinkage, that transverse or shrinkage cracks occur. It is also during this period that the reinforcement is of little or no value, for there is no bond until the concrete hardens.

Curing Concrete. To offset this shrinkage, sometimes called contraction, during the period between the time the concrete is placed and the time it sets, and has strength, it is absolutely essential that effective curing be had immediately following the time of final finishing of the surface in order that this cracking might be eliminated. The development of this cracking as a result of too rapid drying out and ineffective curing is far more apparent in long length slabs than in the shorter ones. It would therefore seem that the slab lengths should be greatly dependent upon the effectiveness of the curing to be done.

Safety Guard on Concrete Mixers

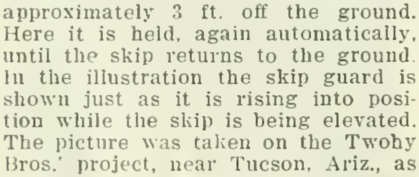
Chain Belt Co., Milwaukee, is now equipping its Rex pavers with an automatically operated guard which prevents workmen, or others, from getting beneath the charging skip while it is elevated. The device is a patented one. It completely surrounds the skip buckets but in no way interferes with the charging of the paver. When the skip is down and the guard is not needed, it rests on the ground. Trucks and wheelbarrows can pass over it while boxes can be transferred from industrial railroad cars to the skip without interference from the guard. As the skip rises, the guard also rises automatically, to a position approximately 3 ft. off the ground. Here it is held, again automatically, until the skip returns to the ground. In the illustration the skip guard is shown just as it is rising into position while the skip is being elevated. The picture was taken on the Twohy Bros.' project, near Tucson, Ariz., as members of the Arizona Highway Commission were passing the Rex paver on an inspection trip.



Skip Guard for Mixer.

New Gasoline-Operated Crane

Stability due to low center of gravity and concentration of weight over caterpillars (no outrigger's or jacks are required); simplicity of control, and mobility are features of a new gasoline-operated crane, brought out by the Penn Bridge Co., 101 Park Ave., New York City.



The "Beaver" Crane.

A further feature, exclusive with this machine, is the triangular sill construction at the center of the first axle which permits the steering wheels to ride over obstructions without distortion of the main car body. The short tractor platform allows the front axle to steer the crane in a 16 ft. radius. The crane has no complicated machinery requiring protection from the weather—the hoist drums being located beneath the platform, and all gears enclosed in oil casings. The crane has a nominal capacity for ½ yd. clam shell in sand, ¾ yd. clam shell in coal, 2 tons on the hook, all at a 25 ft. maximum radius. It has a maximum capacity of 4 tons at 12½ ft. radius or at 20 ft. straight ahead. The height to top of mast is 12 ft.; width over caterpillars, 10 ft., wheel base, 9 ft.; boom length, 34 to 40 ft. The total weight is approximately 10 tons. Steering radius for crane, is 16 ft., and the total boom swing is 315 degrees. The power plant is a 40 h. p. 4-cylinder motor.

New Trailer

A new trailer, designed particularly for use with tractors, has been placed on the market by the Miami Trailer Co., Troy, O. This trailer is of all steel construction except wheels and tires. It has a rounded load capacity of 2 yd., with provision for mounting a separate flared top box of ½ yd. or 1 yd. extra capacity for transporting materials of a total load of 2½ tons, but of greater volume than 2 cu. yd. With ample factor of safety, the carrying capacity is 2½ tons. The body, which is of 10 gauge steel, well reinforced with heavy angle arms, is designed with a rear bottom dump door, so that the size of the opening may be controlled either to dump the entire load in one spot, or to spread the contents 60 yd. wide to any depth desired. The entire load dumps back of the axle and behind the wheels of the trailer. The load is practically balanced on the axle, sufficient weight being placed on the drawbar to prevent wear in the hitch connection. The special automatic hitch bolts on to the rear housing of the tractor. The tractor is simply backed up to the end of the trailer drawbar and the coupling is completed without pins or cotter keys. Only a slight upward pull on the drawbar is necessary to disconnect the trailer from the tractor. Both release and winding levers of the trailer are placed at the right hand of the tractor driver. This eliminates the necessity of stopping to dump or spread the load, or to rewind the dumping door.

Miami Tractor Trailer Unit.

New Secretary for National Paving Brick Manufacturers' Association

Edward E. Duff, Jr., has been elected Secretary of the National Paving Brick Manufacturers' Association and will assume office on or about Jan. 1st. Maurice B. Greenough, retiring Secretary, will become associated at that time with Mr. W. M. Lasley, of Chattanooga, Tenn., in various enterprises, including the manufacture of paving brick. Mr. Duff comes to the National Association particularly well fitted to assume charge of its increasing activities. Following several years of experience in railroad engineering with the Pennsylvania R. R. he spent several years in municipal engineering and management at Sewickley, Penna. When the United States entered the war he was commissioned and served for two years with the A. E. F. in France as Captain of Engineers. This, with his subsequent experience as field engineer for three years with the Eastern Paving Brick Manufacturers' Association, places him in a position where he can be of service in the street paving and highway construction field as well as in the paving brick industry. Mr. Duff is a graduate of the Department of Civil Engineering of Carnegie Institute of Technology where he was awarded the degree of B. S. in C. E. in 1913, and in 1917 the degree of C. E.

Nearly 11,000,000 Motor Vehicles in U. S.—According to the U. S. Bureau of Public Roads, 10,620,471 motor vehicles were registered in the United States on July 1.

Waterworks and Hydraulics Issue

ENGINEERING AND CONTRACTING

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Roads and Streets—1st Wednesday
(a) Roads (c) Streets
(b) Quarries and Pits (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works (c) Sewers and Sanitation
(b) Irrigation and Drainage (d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance (b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges
(c) Harbor Structures

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Who Is to Blame for Inadequate Salaries?

Most men engaged in the construction or operation of large properties are thoughtful—thoughtful, that is, beyond the average of men in general and even beyond many others of similar standing in their communities. The thoughtful man is not hasty in placing blame: he is apt to think of his own shortcomings before censuring another, and he knows that it is not every trouble that he can blame either upon himself or upon any other individual. Nevertheless we believe that the thoughtful and poorly paid water superintendent can assign the cause of his inadequate remuneration to a few quite definite classes and in many instances undoubtedly to particular men. Seldom will it happen that the cause lies wholly at one point.

First of all he can generally say to himself, "It's true that I like my work, that my profession gives me respect and standing in the community, and that I would not like to change my occupation. Nevertheless I am dissatisfied because I know I am not getting paid what I am worth. There are hundreds of men right around here whose work is not to be compared with mine in importance nor in the ability required to perform it, but who get paid altogether more than I get. Some of these fellows are a good deal like I am and are doing their work largely because they like it, but most of them are out for the money and are going to play every card they have to get it.

"Personally I guess I've been both overmodest and timid. I have figured I could get along somehow on what I am paid, and certainly I don't want people in this town to think that I'm after the whole earth. Then I've been a little leary about pushing things too hard because if I got one of those councilmen in a hole where he had to take a definite stand I might make him sore at me, and you never can tell what fool thing a council will do when somebody gets sore. All the same it's damned aggravating to have to put up with the treatment I get.

"Look here! When I'm working for the city I'll scrap to the limit to get just all that is coming to it. Haven't I a perfect right to do just as much on my own account? If I'm any good at all as a scrapper I certainly ought to be able to fight for my own interests. Of course I don't want the whole earth, and nobody that is honest will say I do. All I want is a reasonable pay for my services, and so far I haven't made anything but a feeble effort to get it. I'm going after it now in just the same way that I go after a proposition for the city's benefit."

If superintendents are often partly to blame for their own unfortunate situations, politics and politicians are usually still more responsible. Salary increases are conspicuous, and it takes a nervy councilman to come out boldly for them when voters are complaining loudly of high taxes, and when he knows that the public servant will probably stick to his job even if he doesn't get paid reasonably. Extravagance and waste in some lines will hurt the politician less than efficient expenditure in others.

It is easy to lay a goodly part of the blame for poor salaries on the shoulders of the politicians, but it is less easy to find means for remedying the condition. The politician, himself, is the victim of a system; and with the best of desires he may consider that public expediency requires him to do many things he would rather not. Pressure may be brought to bear upon him either through general publicity or through concentrated or organized voting power. If the press can be sufficiently interested, public opinion may be brought to favor better salaries either as a matter of justice or because it is convinced that real efficiency lies therein. It is often possible to interest influential groups or organizations, and to secure action through them where it is not possible to reach the public directly; and in this day of numberless clubs, associations and societies it is not usually difficult to find one or more to take up any just cause.

But we started out not to be overharsh on anyone because of the misfortune in which we find many superintendents. We have had the superintendent blaming himself and everybody blaming the politician all, as we think, justly; but there are other less tangible causes in which no small part of the difficulty lies. Public apathy is very real though not easy to locate. The public can be made to understand that it may be just as bad business to pay a man less than he is worth as to pay him more, but that is a long and difficult process. Generally it is easier to prove to it that an injustice is being done, and to secure its action through sympathy. Then there is custom. Small salaries to public servants are customary, and so small salaries continue even when their undesirability is quite demonstrable.

We have discussed the subject of salaries before, and we shall discuss it again, for it is a matter which, quite aside from its personal importance to every head of a water department, has a vital bearing on the proper and efficient operation of our plants.

Watershed Protection and Forestry

Some of our cities own or control extensive watershed areas in order to maintain the purity of their water supplies; and others are considering or seeking such control. In many cases the large expense thus entailed can be to some extent offset by the judicious use of the land for forestry. In general there is no competitive use, such as agriculture, to which the ground can be put, so that in estimating the benefit to be derived from a program of forestation no charge need be made for the use of the land.

Newspaper piffle about tree planting and reforestation ought not to make us callous to the fact that the rapidity with which our forests are being cut makes a tremendous increase in the cost of timber inevitable in the not remote future. Where present prices would not pay the cost including interest of producing a crop of timber, prices of the future may make the investment a highly profitable one.

The water supply will usually be benefited by a forest cover for the shed. Run-off will be slowed down, and turbidity and silting will be checked.

Not only may the land properly be considered as free of cost for this purpose, but economies of care are possible beyond what could be secured in simply a forest project. Both forest and watershed need patrol and observation, and there appears no good reason why one man should not perform the service for both simultaneously. Trails are necessary in both, and sometimes roads. Other opportunities for economy in combined operation are certain to be found when the work is undertaken.

The city entering at this time upon a carefully planned program of forestry its watershed lands make a comparatively small investment which brings an immediate improvement to the quality of its water supply; and which, as far as present foresight can tell, will bring a substantial profit to the city of two or three generations hence. Some good beginnings have been made in this direction. There should be many more.

The Rising Importance of Water Purification

Increased demands for water for use by cities, and the lessened opportunities for securing uncontaminated supplies, are vastly increasing the use of purification systems. Easily available supplies of pure water have practically ceased to exist—either because they have long since been appropriated or because habitations and industry have expanded over watershed areas that once were clean.

Cities that formerly had abundant supplies of good water have increased in population beyond expectation at the same time that per capita consumption has increased, until the old supplies have become entirely inadequate, and the cities have been forced to augment them with water brought from a great distance or with water purified from what was once considered a wholly unsuitable source.

In the public mind there still lingers the idea that pure water can only be had from a pure source, and so strong is this idea that it sometimes leads to the expending of needlessly large sums in bringing water from a distance, when much cheaper and equally wholesome supplies could be had by taking water near at hand and purifying it by approved modern methods.

More instances of this sort should not occur, for the waste of public funds is as inexcusable as is the waste of private. The makers of purification apparatus and supplies may properly plead the cause whenever the issue arises, but they are not the ones whose arguments are likely to prove most effective.

Engineers and engineering societies should harp before the public on the fact that by proper treatment an admittedly contaminated supply may be rendered thoroughly suitable for domestic consumption, and may, in fact, be much purer than a vastly more expensive supply brought from a distance without purification.

Book Reviews

Sewerage and Sewage Disposal.—A Textbook by Leonard Metcalf and Harrison P. Eddy. First edition. McGraw-Hill Book Co., New York and London. Cloth; 6x9 in.; pp. 598; illustrated. $5.00.

The authors state that they have prepared this volume in response to a demand for a textbook for engineering schools. It is an abridgment of the three well known volumes of "American Sewerage Practice," published by the same authors in 1914, in which the meaty portions of the larger edition, have been retained. Some additional sections and explanations have been included to bring the book up to date and to make it more easily understood by students. The book is written by engineers who form their ideas and make their recommendations with many years of experience as a basis.

The first two chapters on quantities discuss the amounts to be expected from house sewage, ground water infilteration and industrial sewage in separate systems, and the quantity of runoff to be expected in storm or combined sewers. Methods of determining runoff from the use of formulas are described but particular stress is placed upon the rational method of determination as giving the most logical results. Having obtained the quantities, the student is given methods of obtaining the size and type of sewer necessary to carry the flow. Next follows a chapter on the appurtenances used in conjunction with sewer systems, such as manholes, inlets, siphons, flushing devices and pumping stations.

Two chapters describe the construction of sewers and the materials which go into a system.

Practically all of the remaining chapters are devoted to sewage and various methods of disposal. There is a discussion of the constituents of sewage and the significance of the various changes which take place in its decomposition. An outline of laboratory analytical routine tests follows:

All the successful methods of treatment and disposal of sewage are described, there being a chapter each, on disposal by dilution, the use of grit chambers, sedimentation and septic tanks, the Imhoff tank, and the activated sludge process. All of the processes are illustrated with examples of plants in actual service and data on their operation are given.

The problems connected with the disposal of the accumulating sludge are dealt with in an instructive manner.

The secondary and final methods of treating sewage, which are necessary in many places where a higher degree of purification is required, are discussed in considerable detail in chapters on contact beds, trickling filters, and sand filters. The various methods of dosing the beds are illustrated.

The disinfectant of the final effluent of a sewage treatment plant is a study in itself and the authors have described how the various disinfectants such as liquid chlorine, copper sulphate, and acids are most and effectively applied.

A brief chapter is devoted to irrigation with sewage and the final chapter takes up cost accounting and estimating.

Throughout the book the authors impress the reader with the experience which has been drawn on to make the volume serviceable.

Sewerage and Sewage Treatment.—By Harold E. Babbitt, M. S., Assistant Professor, Municipal and Sanitary Engineering, University of Illinois. John Wiley & Sons, New York. Cloth; 6x9; pp 531; illustrated. $5.

The author states that this book is obtained from class room and lecture notes developed and expanded into a general treatise on sewerage and sewage disposal for the use of students and practicing engineers. The work is somewhat general in its treatment and inclined to suggest the use of formulas for the solution of many of the problems, although many illustrations and examples are drawn from practical work.

The first few chapters outline the general procedure necessary for the design of a sewer system, and include studies to determine future growth in population, quantity of sewage and storm water flow, an outline of the rational method of sewer design, hydraulics of sewers, and suggested methods of laying out sewer systems. A chapter on appurtenances discusses details of the necessary adjuncts of a sewer system such as manholes, inlets and catch basins, regulators and other details.

A chapter on pumps and pumping stations is principally a catalog of different types of pumps commonly used in sewage pumping stations with their operating costs and performance.

Another section consisting of several chapters deals with sewer materials, contracts and specifications, sewer construction and maintenance. The construction of sewers is taken up in considerable detail and includes such items as cost estimating, methods of excavation, bracing and sheeting, tunnel work, and methods of design and construction of the various types of sewers.

The last section of the book treats

of the composition of sewage and the various methods of sewage treatment. These methods are disposal by dilution, screening, sedimentation, both plain and chemical, filtration and irrigation. There also is a chapter on the more recent activated sludge process. There are also brief sections on the Miles acid process, disinfection, and electrolytic treatment, which is dismissed with a few peremptory paragraphs.

A limited space is devoted to sludge disposal, a topic of most importance to all sewage treatment plant operators. The various methods are briefly treated and results obtained at different places are quoted.

Perhaps the author has intentionally tried to cover a wide field in the book and is, therefore more general than specific. The specific application is largely a question of experience and this book deserves a place as a general guide of this nature.

"Do Engineers Think?"

To the Editor: Mr. A. M. Van-Auken's letter "Do Engineers Think?" published in your recent issue has struck a responsive chord in the writer.

But why pick on the engineer?

I number, among my friends, several who do not hesitate to admit that they are engineers. As far as I have been able to ascertain to date, these engineers are closely related to the human species and possess many fundamental traits peculiar to the Genus Homo.

I have found in my journey through this "Vale of Tears," that, generally speaking, a man is as lazy as he dares, or deems it expedient, to be. I have further found that informing this man of said fact, even in words pregnant with no uncertain meaning, is but effort wasted. But change this man's viewpoint and you change his whole course of action.

A case at point: A few years ago the concern with which I was connected was starting a building and was at the heartbreaking stage of trying to keep enough men at work, in muck half-way to their knees, to get it dug out and reach the solid ground underneath. Men would work from half a minute to half a day and fade away and vanish.

One morning the superintendent and myself were overlooking the mess and trying to devise some scheme to speed up the work. Suddenly and unannounced, a raw-boned pigmy of some six odd feet in length, wearing a pleasant smile and a square jaw, butted into the picture with a request for work. The superintendent started in by asking him if he preferred ping-pong or tiddlewinks. He then waxed eloquent. Here was an opportunity, not to be lost by said superintendent, to lay before me his innermost thoughts regarding the work and regarding men in general in a perfectly impersonal way so far as our relations were concerned. In conclusion he said: "If you are the man that I have you sized up to be, I'll make you a foreman, otherwise I'll fire you. I didn't ask you to take this job and by dad if you don't perform I've half a mind to kill you."

By this time my superintendent had not only got it all out of his system, but he had actually sold this man a bigger job than he thought himself capable of handling. He went to work. His hole hit bottom first. A few nights later we put on a night shift with this man in charge. He was 30 years old and had never got beyond being a laborer because no one had ever sold him a better idea. Never, from the time that this man got his gang organized until the excavation was completed and the concrete poured, did the day gang show as low costs as this man was able to produce.

That was three years ago. Today that man has complete charge of extensive field operations, in one section of the country, for a very large construction company. Now he was not an engineer, but he had never thought very much about thinking. He has since formed the habit of reading and has even expressed some curiosity regarding how to go about figuring out how strong things ought to be made so they won't "bust and mess up the tea party."

Men do not think for pleasure. They think only from necessity and not even then if they do not feel impelled to do so.

A horse breeder once told me that the real value of a horse was in his colthood; that a rather unpromising colt, properly handled and fed, often developed into a good horse, but the best colt ever thrown from a dam could be completely ruined by improper treatment and feeding.

I would ask Mr. Van Auken to visit any school room in Chicago. I lived there a good many years and had children in the public schools. What will he find? It is a thousand to one shot that he will find this room crowded to capacity. He will find it presided over by a tired, capable little lady giving her very heart's blood in a brave struggle to hold the attention and arouse the thinking apparatus, to logical functioning, of possibly forty to fifty, yes, and in some cases sixty, active young pirates of half a dozen nationalities, whose chief joy in life is to "get teacher sore."

Now from Chicago travel the length and breadth of this country. A country which our forefathers wrested for us from the forest and the prairie and gave to us, along with the constitution and school lands, a priceless heritage. In every growing city we find the same over-crowded condition of the schools.

Is there something fundamentally wrong with our public school systems that our children are not being taught better? Must we tear down and rebuild in order that we may, on our part, leave to posterity institutions which will develop, in fullest measure, the powers of thought of those to come?

Face this question fairly. Ask any school principal to explain the subjects taught in the primary school and their sequence, together with the underlying scheme to systematically arouse and develope the child's mental capacity and give him mastery through conscious power to think logically and consistently. Go to the normal school and see the wonderful course in pedagogics in which the future teacher is drilled before she is pronounced fitted to fill her sacred office. Then look at that girl ten years later, worn into almost an old woman trying to do the impossible. Then ask the question: "Do Engineers Think?" Then ask the question: "Why have our sons and daughters not learned to think more clearly; why have they not learned to make the most of their opportunities?"

A slice of bread may be delicious and nourishing, but it would hardly make a meal for a family of six.

A few years ago we formed the habit of thinking that it was a very nice thing to give until it hurt in order to discourage Kaiser Bill from making an American tour. Similarly, each one of us who has the honor of being an American citizen should be anxious and willing to give, and give as we never have before given, to increase the taxes for public school purposes and then to see that these funds are judiciously expended to increase our primary schools to the point where proper individual instruction may be given each child and that the teaching staffs may be so increased that each teacher shall not only have the opportunity of studying and developing her individual charges, but that she may have enough reserve vitality, at the end of her day, to feel that she is still a woman free born and that life possesses other joys besides those found in July and August.

Teach the child to think and make it possible for the teacher to think that she has Opportunity where she can use it to the full.

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Multiple Arch Dams

To the Editor: Your recent article on "Dam Construction in America" was noted with great interest. Permit me to point out a few facts which may be of some interest in view of the large number of dams which are contemplated for the near future.

Most arch dams as heretofore constructed, were designed as cylinders exposed to an external water pressure. The fact that such dams are "encastro" at the base as well as along the side abutments, was generally neglected, and little attention was given to the stresses which occur from gravity or vertical cantilever action. Observations of the deflections of arch dams have shown that the maximum deflections usually occur at the crest, and that practically none exist at the base, although according to the cylinder theory the opposite might be expected. Such an absolute disagreement between theory and actual conditions should be a sufficient inducement for attempting a more scientific design of arch dams.

An interesting arch dam was recently built on the river La Jogne in Switzerland. The design was based upon the theory of an elastic structure, and the dam was shaped in such a manner as to insure harmonious action between vertical cantilever and horizontal arch elements.

In order to obtain comprehensive information regarding the statical conditions of arch dams, and to establish reliable assumptions for future designs, the Engineering Foundation started recently an investigation of arch dams by making tests and measurements on a large number of characteristic structures of this kind. It is hoped that accurate measurements of stresses, deflections, temperature variations, etc., extending, if necessary, over a number of years, will furnish reliable assumptions for a safe and economical design of future arch dams.

As the use of single arch dams is restricted to comparatively narrow canyons, structures of the multiple arch type have been built quite frequently during recent years both in America and in Europe. For instance, about six to eight multiple arch dams are under construction in Italy, one of these dams to be over 200 ft. high.

In Sweden, two multiple arch dams are being built about 100 miles north of the Arctic circle, and under the most severe weather conditions. These dams are designed for ice pressure resulting from a sheet of ice 10 ft. thick. Such facts indicate clearly the increasing favor with which the modern kinds of dams are viewed.

In the United States an improved type of multiple arch dams has been developed recently, and several structures of this type from 200 to 300 ft. high are contemplated for construction in the near future. Careful investigations have shown that such dams have a factor of safety at least twice as high as straight gravity dams of standard cross section. Nevertheless, the cost of such multiple arch dams will be only about one-half the cost of gravity dams, and the time for construction is reduced about one-third.

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Appreciation of the Engineer

Editorial in the August Journal of Engineering Institute of Canada.

It is not often that the engineering profession receives a tribute and there are few records to show an appreciation of what the engineer is, what he is doing, and what are his possibilities, to compare with that offered by Doctor Frank Crane in a recent issue of "The American City." It is hoped that every member of the profession will read this and while the modesty of the average engineer will forbid it, it affords material for conversation with those not in the profession, and for newspaper publicity, in order that the average man may know better what is owing by him to the engineer. Doctor Frank Crane, whose reputation as a philosopher is growing yearly, says:

> The man of the future will be the engineer.
>
> He is the man who can do things; and is better than the man who owns things.
>
> But the official who will forever be indispensable is the engineer.
>
> The time will come when the President of the United States will be chosen as the man who has the greatest talent and skill in organizing public works. There will be no more politics in his selection than there is now in choosing the master mechanic of a railway or factory.
>
> When a nation goes to war nowadays, that is, when it becomes necessary to exert its supreme collective strength, nobody dreams of selecting the most popular politician or the cleverest speechmaker to lead the armies. It is the man who can get the last ounce of efficiency out of men and metal that is wanted.
>
> Some day the nation will realize that it is continually in a crisis, and that in peace as in war we need the highest order of efficiency and organization.
>
> We need the engineer to arrange the transportation of people and goods from place to place, without waste, without competition, without graft, looking only to the public good.
>
> We need the engineer to get meat, bread and milk from farm to citizen, without the present inefficient tangle of trusts and middlemen working at cross purposes.
>
> We need the engineer to turn the profit of public enterprise toward building good roads and bridges, instead of enriching a few shrewd manipulators.
>
> We need the engineer to manage a city as economically and smoothly as if it were a manufacturing plant.
>
> We need the engineer to organize the farmers so that all can work together for each and their products be marketed without being preyed upon at every step of the way from farm to household.
>
> Wealth can be taken away from us. But the power to do things cannot be taken away.
>
> The millionaire could go and not be missed. The engineers we cannot spare.
>
> "What availeth all thy wealth?" said the ancient philosopher. "He that hath better iron than thou will come and take away all thy gold."

Says H. L. Gantt:

> "The man who knows what to do and how to do it is preeminently the engineer. The new world which is being ushered in by the great struggle now taking place is one in which the engineer is destined to be the supreme power, for it is becoming clear that, in future, the man who owns things will not be as important a factor in the world as the man who can do things."

Reading this panegyric should give a man an added pride in his profession. But that is not sufficient. This is the information that engineers should keep constantly before those in high places, in order that we may not have again conditions as have existed recently. We know thoroughly trained and capable engineers who have been unable to find positions when the country stands in need of the production their training and experience can effect for the benefit of the country. Too long the engineer has been overly modest and today the whole profession is suffering as a consequence. Undue modesty is a curse which has reacted heavily upon the position and standing of engineers.

If the lesson has not been learned, the outlook is not promising, but if we have learned our lesson it is obvious that we should on every possible occasion do a little shouting on behalf of the profession in order that the world at large may really know what engineers have done and are doing, and of the super-important position they occupy in the development of a country such as this, which at the present time is not even in the slightest degree recognized, as was pointed out at the recent meeting in Vancouver.

Accident Compensation for Contracting Typhoid Fever.—According to a ruling of the Michigan Department of Labor handed down early last month, as reported in the daily press, where an employe contracts typhoid fever by drinking water furnished by his employer, the employe is entitled to compensation. According to the files in the case, an employe of a hotel contracted typhoid fever as a result of drinking water furnished by the hotel to its employes. The state board awarded her compensation on the ground that contracting the disease was an accident and that the accident occurred through the negligence of her employer through their failure to supply pure drinking water. Several supreme court decisions are quoted in the findings in which it has been held that the contracting of disease is accidental and in which employers are held liable when disease is the result of negligence.

Parking Automobiles on State Highways

Parking automobiles on the pavement of narrow state highways is exceedingly annoying and dangerous and should be eliminated in view of greatly increased automotive travel, in the opinion of state highway officials of Indiana. If one has occasion to park a machine on a narrow state road, then it should be driven out on the shoulder of the highway where it will not obstruct traffic, they point out.

The Indiana commission has authorized district engineers and superintendents to watch for machines parked on narrow roads, and instructed them to take the matter up with the owners, explaining the inconvenience to which the traveling public is subjected; also the danger.

A. H. Hinkle, superintendent of maintenance for the state highway commission, points out that frequently machines are parked on both sides of country roads so as to almost block traffic or, at the best, to permit only one way traffic through the narrow lane between. This is customary, he says, in front of country churches, picnic grounds, base ball grounds, pleasure resorts and stopovers. He cites a case of where not long ago a road was blocked except for one way traffic in front of a church where a funeral was being held. Owing to the obstructed road an accident occurred, which might have resulted in the death of another individual.

Mr. Hinkle points out that everyone who is forced to park a machine on a heavily traveled highway, should bear in mind the danger to which the auto is subjected. Not only is there danger to the party wishing to pass, especially if two cars traveling in opposite directions attempt to pass near the parked auto, but also to the parked car itself. When such a condition exists one of the machines endeavoring to get around must go into the ditch or a wreck results.

The Indiana highway commission contemplates erection of signs near all ball parks, public parks, resorts, et cetera, warning against parking cars on the pavement and urging parking on the shoulders or sides of the roads.

Growth of Federal-Aid Roads.—More than 1,000 miles a month has been the rate of growth of completed Federal-aid roads during the present working season, says the Bureau of Public Roads, United States Department of Agriculture. The mileage completed on August 31 totaled 19,308, of which 6,401 miles have been added since the beginning of the year. On the same date there was under construction 14,670 miles. Federal-aid roads in all stages, from approved projects to completed roads, now total 41,405 miles, or 23 per cent of the system of highways being outlined by State and Federal engineers to serve the whole country, and which will consist of approximately 180,000 miles.

The Scituate Dam of Providence Water Supply

Construction Features of Earth Dam With Soil Core Described in Paper Presented September 14 at Convention of New England Water Works Association

BY FRANK E. WINSOR

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The main dam for the Scituate Reservoir of the new water supply of Providence, R. I., will have a length of about 3,200 ft., a maximum height above the valley of about 100 ft., and a maximum height above bed rock of about 180 ft. It will have a maximum thickness at the base of 640 ft., and a thickness at the flow line of 118 ft. The width on top, 13 ft. above the flow line, will be 37 ft. The cubic contents of the dam, including refilling below the surface of the ground will be about 2,500,000 cu. yd.

Excavation in Deepest Portion of Core Trench Showing Lowest Steam Shovel Operation and Removal of Material by Trains.

The cross sections of the valley, the character and depth of the material overlying the rock and the ease and economy of construction of an independent masonry spillway founded on rock clearly indicated an earth dam to be the best and most economical type for the main dam. Subsurface investigations of the material overlying the bed rock showed it to be a modified glacial drift varying from very fine sand to coarse gravel with very irregular stratification and freely water bearing. The materials encountered in the excavations so far made agree very closely with those indicated by the borings. The underlying rock is a granitic gneiss of fairly uniform quality and no fault appeared in the bottom of the rock valley.

Stream Control During Construction.—The control of the stream during construction was accomplished by diverting it into a horseshoe-shaped conduit 25 ft. wide by 21 ft. 4 in. high and 462 ft. long passing through and under the dam with its bottom elevations substantially the same as the old river bed. This conduit is founded upon ledge rock and is connected with the river by approach and discharge channels about 1,000 ft. and 200 ft. long respectively. The approach channel is lined with concrete up to the height of ordinary river flows, mainly with the idea that the percolation into the deep portions of the core trench during construction might be reduced thereby. The upstream and downstream sides of the deep excavations are guarded by earth embankments forming the toes of the dam and referred to as the upstream and downstream cofferdams. The upstream cofferdam is at a sufficient height to provide without being overtopped for the continuous passage of about 150 second feet per square mile through the stream control conduit.

Provision for a flood of this unusual magnitude was considered necessary because of the important mill properties on the stream below the dam which might suffer great damage if accumulated storage was suddenly released by the failure of an inadequate temporary structure. It was also very important to avoid any possibility of flooding the deep portion of the cutoff trench during its excavation and refilling. The largest runoff per square mile in this vicinity, of which any reliable record has been found, occurred in February, 1886, from about 32 square miles of this same drainage area when a peak of undoubtedly short duration of about 140 second feet per square mile occurred. The storage below the top of the upstream cofferdam is about 2½ billion gallons, the accumulation of which would materially reduce the peak of a short quick flood at the dam.

The Gate House.—The gate house is located about 60 ft. upstream from the center of the dam and over the stream control conduit. When the embankment of the dam is substantially completed a steel and wooden bulkhead will be built at the upstream end of the stream control conduit and a temporary cofferdam near its lower end. The ordinary dry season flow of the stream will then be carried in a 36-in. steel pipe already laid in the masonry invert of the conduit, while the conduit is being plugged at the gate house and permanent stream control gates, etc., are provided. After the closure of the conduit is completed the 36-in. pipe will be permanently closed and the filling of the reservoir begun. The river control conduit downstream from the gate house will be divided by a horizontal floor about half way up, upon which will be supported the pipes which carry water to the city and below which will flow the water released for use of the mills downstream. The gate house will be equipped with shutters which will provide for drawing either city or mill water substantially from the bottom, from a depth of about 47 feet or from any depth down to 32 ft. below full reservoir level. The gate house is also designed to permit the installation of turbines capable of developing the power available from either city or mill water passing through the dam. A Venturi meter for measuring the flow of mill water will be provided

General View of Deep Portion of Core Trench Showing Last Stage of Track System for Excavation.

near the downstream end of the conduit.

The approach to the spillway of the reservoir is separated from the main dam near its west end by a knoll of ledge rock extending slightly above the top of the dam. A 3-span reinforced concrete arch bridge about 250 ft. long extends over this arm of the reservoir near the spillway and connects the public road to be built over the dam with the main land.

The Spillway.—The spillway is a solid masonry structure with a maximum height above rock as indicated by the borings of about 20 ft. and with a gross length of about 440 ft. The net length is about 413 ft. and a platform will be provided about 4 ft. above the crest from which low flashboards can be placed to prevent the loss of water due to wave action when the reservoir is full. The length of spillway is conservatively designed in connection with the great area of the reservoir to take care of any possible floods without unduly raising the water surface. The minimum elevation of the top of the main dam and dike is 13 ft. above the flow line of the reservoir and the higher portions of the structure will be built with an allowance for ultimate settlement to this minimum. After falling over the spillway the waste water will be conducted back to the river through an excavated channel about 1,800 ft. long with the bottom, except near the river, in rock.

The Soil Core.—It was necessary in order to make a tight dam to provide an impervious cutoff down to rock. A thorough examination indicated that soil and subsoil were the only materials available in sufficient quantity and of dependable uniformity for making a water-tight cutoff. The material underlying the subsoil within a practicable distance of the dam is modified glacial drift, very similar in its general characteristics to that encountered in the excavation of the cutoff trench. Its very variable character and the absence from large portions of it of fine materials precluded its use for the core.

A masonry core wall was considered and estimates of cost were made with various designs. It was not deemed good design, on account of the very porous character of the material available for the abutting fill, to depend for watertightness solely upon a nonstable masonry wall, of any dimensions economically practicable, which would be apt to crack under unbalanced pressure, and all designs for masonry cores contemplated a considerable amount of soil and subsoil on one or both sides of the wall. The placing of the soil would be complicated by the presence of the wall and it was concluded that a more satisfactory and more nearly watertight structure could be obtained under the conditions which here prevail by the adopted design, which contains about 2½ times more impervious material than the minimum considered with the masonry wall and has also the advantage of considerable economy over any design of masonry core considered.

Why the Soil Core Type Was Selected.—The possibilities of hydraulic dam construction were considered at great length, and it was finally decided to require that the impervious core be placed in thin layers (not more than 6 in. after rolling) wet and rolled with heavy rollers. There were several reasons for this conclusion, some of which are as follows:

(1) The excavation and refilling of the deep portions of the core trench with a maximum depth of 80 ft. and a length of over 1,000 ft. had to be done generally below the ground water level and the placing of watertight material under these conditions (such material aggregating about one-fourth the entire amount of this material required in the dam) could it was believed be only satisfactorily accomplished by a dry method.

(2) The borrow pits available are so varied in character and contain so many large masses of very coarse material that it was considered unsafe, for the portion of the dam above the ground water level, to depend upon them to produce sufficient fine material to secure a satisfactory watertight core, if deposited by the usual hydraulic method of dam construction.

(3) The soil and subsoil which are being used in the core could it was believed, even in the upper part of the dam, be as economically placed in position by the dry as by hydraulic methods, particularly when it is considered that a plant for placing about ¼ of it in the dry would be required for the portion of the dam below ground water level.

(4) All the borrow pit material practically available lies in the valley upstream from the dam and to place it in the dam hydraulically would involve lifting to a maximum height of about 90 ft. The material contains considerable amounts of coarse gravel, cobbles and large boulders which would render pumping very difficult and expensive.

The contractor was given an option in the manner of placing the material outside the soil core and he has decided to place substantially all such material with cars, either deposited in 2-ft. layers consolidated by heavy hose streams or under some conditions dumped into pools of water.

Specifications for Placing Material.—Some clauses in the specifications for the dam affecting the placing of materials are as follows:

Sec. 11.5. Impervious Embankment of Soil, Item 11. Under Item 11 the Contractor shall furnish and place the impervious embankment of soil in the core of the dam and dike and in the upstream face of the cofferdam begun under a previous contract, and elsewhere if directed. Material for this portion of the embankment shall consist of top-soil and subsoil, free from vegetation occurring above the ground surface, masses of roots or individual roots more than 24 inches long or ½ inch in diameter, large stones, porous materials and other undesirable matter. It shall be of acceptably impervious quality. Top-soil containing an excess of organic matter and silt and muck will not be acceptable. Suitable materials from the excavations may be used in the soil embankment. The remainder shall be obtained from approved locations within the reservoir limits but not closer than 500 feet to the upstream toe of the dam and dike. Such additional material shall not be included for payment under any excavation item, but all cost of excavating and hauling it to the dam and placing it in the embankment shall be included in the price stipulated for Item 11, however great the haul required. The most convenient areas immediately upstream from the dam from which acceptable soil can be obtained are indicated on Sheets 9, 10 and 11 of the contract drawings. To obtain sufficient acceptable material from easily excavated areas it will be necessary to go beyond the areas shown. Acceptable material for impervious embankment will generally be found only upon upland areas and many large cleared areas in or near the bottom of the valleys, the most extensive of which are near the main dam, will not be permitted to be used owing to the presence of silt, sand and an excessive amount of organic matter. Material placed under Item 11 shall be rolled in 6-inch layers in the manner specified in Section 11.6. Care should be taken in starting the soil embankment for the core to secure thorough filling in all irregularities in the bottom of the trench and a compact bearing of the soil on the top and edges of the concrete covering of the rock and the cutoff walls, described in Section 17.24, without damaging the masonry. This work will require some hand placing and tamping and shall be done with great thoroughness

Sec. 11.6. Rolling. Refills and embankments of soil placed under Item 11 shall, unless otherwise permitted or required, be deposited in approximately horizontal layers not exceeding 6 inches in thickness when compacted, and unless sufficiently moist as spread shall be wetted in such manner as will secure the uniform moistening of all portions of each layer. The compacted surface shall be acceptably sprinkled immediately before placing each new layer. Each layer shall be rolled by approved rollers having grooved or banded rolls. The heaviest wheels of the roller shall cause a calculated average pressure of at least 30 pounds to the square inch on a bearing surface considered as the width of the roll multiplied by half the arc bounding a segment of the roll, at the bottom of the grooves, having a middle ordinate of 1 inch. The roller shall pass over every part of each layer that can be traversed by it as many times as may be necessary to thoroughly compact the material. Items 11 and 12 or 13, where contiguous, shall be brought up simultaneously, and the thorough compacting of the soil where it adjoins the previous materials will be essential to avoid an unsatisfactory softening of the embankment from the use of water in compacting the pervious materials. Portions of the refills or embankments which the rollers cannot reach for any reason, shall be compacted by extra-heavy tampers used energetically, or by other means which will secure a degree of compacting equivalent to that obtained by rolling as specified. At the beginning of each season, the surface of the ground or the embankment previously placed shall be carefully cleaned and thoroughly rolled before placing any new material, to consolidate any portions that may have been loosened by frost action or otherwise.

Sec. 11.7. Pervious Filling of Deep Core Trench, Item 12. The refilling of the deep core trench east of the stream control conduit shall be placed by the method outlined in Section 11, unless an alternative plan be approved. The pervious materials each side of the soil core shall be placed under Item 12 in approximately horizontal layers not over 2 feet thick, consolidated by the use of jets of water from hose under pressure and by allowing the ground water to rise in the materials. If fine sand is used for this refilling it will probably be necessary to maintain a considerable thickness of material above the ground water level to avoid conditions like quicksand. It is essential that the refilling materials be thoroughly consolidated so as to avoid subsequent settlement, and special care shall be taken to wash earth and sand into all interstices of riprap and other piles of rock fragments on the side slopes of the excavation as the filling progresses.

Sec. 11.8. Pervious Embankment Above Elevation 195, Item 13. The pervious refilling and embanking for the dam and dike above Elevation 195 shall, unless an alternative plan be approved, be placed under Item 13 in approximately horizontal layers not over 2 feet thick and consolidated by the liberal use of jets of water from hose under pressure or by other effective means. The water pressure shall be sufficient to easily move coarse sand. The quantity of water that will be required for this purpose cannot be predicted and may vary materially from time to time, depending on the character of the embankment materials and other conditions. For the purpose of a rough estimate it is assumed that the equivalent of 8 inches depth of water on each 2-foot layer will be ordinarily sufficient, and much less than this may prove to be satisfactory under certain conditions.

Lowest Point of Dam Foundation, Looking East. Grout Machine With Canvas Cover in Center.

Items 12 and 13 above referred to (Secs. 11.7 and 11.8) are pervious fill both sides of the soil core, and Section 17.24 (referred to in Sec. 11.5) is as follows:

Sec. 17.24. Concrete in Core Trench. The middle 30 feet of the bottom of the core trench, excavated and cleaned as specified in Section 4.8, shall be covered or leveled up with concrete to the extent directed from place to place. This work will generally be done before grouting the bottom. The purpose of this concrete is to fill up the larger irregularities of the bottom, to facilitate the grouting and the placing of the soil core, to seal exposed joints and seams in the rock bottom and to form two low cutoffs near either edge of the 30-foot strip to break the continuity of the contact between the rock and the soil core. Where the bottom is irregular, as was found to be the case for considerable of the portion immediately west of the stream control conduit, the two cutoffs will be provided, but the remainder of the concrete will be placed as best meets the conditions, and the higher projections of the rock bottom, if sound, may be left with no concrete covering.

Progress of Construction.—Construction was begun on a small portion of the main dam in January, 1917, under Contract 3, which provided in part for the work necessary to divert the river and which contemplated completion on Oct. 31 of the same year. War was declared in April, 1917, and owing to the delays occasioned thereby, work on this contract was not completed until December 23, 1918. A second contract, No. 11, was entered into in April 1919 for the completion of the river diversion and for a variety of other work essential to securing the rapid prosecution of construction following the later letting of the major contract. It was expected to complete work on Contract 11 on Dec. 31, 1919, but owing mainly to labor difficulties this contract was not completed until Nov. 1, 1920. With the completion of the stream control work under these two contracts the river was diverted into the horseshoe-shaped concrete conduit, 25 ft. wide by 21 ft. 4 in. high and 462 ft. long, built in solid rock across the foundation of the main dam. The approach channel lined on bottom and sides with concrete about 1,000 ft. long and the discharge channel about 200 ft. long completed the river diversion channel, into which the river was turned on Nov. 5, 1919. Portions of the up and downstream cofferdams were built and about 500 ft. of foundation of the dam immediately west of the river diversion conduit was uncovered, the ledge rock grouted and the trench refilled to the original surface with impervious material. The aggregate value of contract work done on the main dam prior to the letting of Contract 8, which provides for the completion of this work was about $278,000.

View Looking West Toward Stream Control Conduit, Lowest Point of Dam Foundation in Foreground, 80 Ft. Below Former River Bed; Soil Core Being Started.

Contract 8 for the Main Dam and Dike was executed on May 12, 1921. The Contractors, Winston & Co. Inc., erected an excellent camp on an area of about 18 acres of sandy ground situated about ½ mile south of the dam. The camp houses a population of about 400 and is supplied with a suitable water supply, electric lights, plumbing for kitchen, laundry, sinks, etc., the drainage from which is satisfactorily disposed of in cesspools; provision is made for incineration of garbage, and the Kaustine system is used for disposal of human excreta. A thoroughly equipped hospital with attendants is provided at the camp.

Construction Equipment.—The construction of a standard gage railroad about 2.3 miles long connecting the N. Y., N. H. & H. Railroad at Jackson with the dam was completed on Aug. 13, 1921. A high tension power line about 1 mile in length connecting the Narragansett Electric Lighting Co.'s line with the work at the dam was completed Sept. 28, 1921. Electric current is used for lighting, pumping, for operating machine shop and saw mill and for a variety of other purposes. The contractor's equipment in use at the dam consists mainly of 3-ft. gage cars and locomotives, large and small steam shovels, small drag line excavators, steam rollers, one 12-ton traveling cable way crossing the deep excavation transversely, directly connected, electrically driven pumps with a total capacity of about 9 million gallons daily against a lift of about 80 ft., pumps, tanks and piping for water supply, compressor, grouting machine, bottom dumping wagons, mules and the usual rock drills and small tools.

The excavation for the deepest portion of the coretrench was completed, the foundation grouted and refilling begun in August, 1922. Inorder to keep the deep portion of the core trench unwatered, extensive pumping was necessary. The average side slopes of the excavation for the deep portion of the cutoff trench are about 2 horizontal to 1 vertical and the heavy shovels were operated when necessary and without serious difficulty in very fine sand with the line of saturation practically at its surface. The material in the excavation was very variable in stratification and unwatering was accomplished by open pumps below the general level of the excavation in locations where the material was coarse and from which the water was pumped. In one instance the excavation of a sheeted pump well through fine sand to a coarse underlying strata shown by the borings was attempted and after considerable expenditure of time and money was given up because the running in of the sand rendered its excavation practically impossible by the ordinary methods which were available. This same sand when relieved of upward water pressure by tapping the coarse material at some point below it stands up at a steep slope. Had the very fine portions of the materials to be excavated been deposited in horizontal strata, more difficulty would have been experienced in excavation, but with this material existing in pockets even though some of them were very large, little difficulty was experienced, with the aid of the preliminary borings, in selecting satisfactory sites for sumps. The prosecution of the work has demonstrated fully to the writer that, with the material varying from very fine sand, extremely active under water pressure, to gravel and with boulders of all sizes up to several yards in volume, the method of excavation used is the best and most economical.

The experience so far gained has demonstrated that a rolled sand and gravel embankment in thin layers either side of the soil core would have been prohibitive in cost owing to the boulders in the material available.

Preparation of Rock Foundation.—After the earth and boulders have been removed from the core trench the top of the ledge rock is excavated to the extent directed without the use of explosives, the object being to remove so far as possible all seamy, broken and disintegrated rock such as would permit the flow of water from the upstream side of the dam after completion. The entire width of exposed rock bottom is then thoroughly cleaned and scrupulously freed from all dirt, gravel, boulders, loose fragments, etc. Streams of water under sufficient pressure, stiff brushes, hammers and other effective means being used to accomplish this cleaning. The full ordered width of the bottom of the trench then receives special treatment by raking out all remaining seams and cavities and filling them with grout or mortar.

The middle portion of the core trench about 30 ft. in width is then covered or leveled up to the extent directed from place to place with concrete, the purpose being to fill the larger irregularities of the bottom, to facilitate the grouting and placing of the soil core and to seal exposed joints and seams in the rock bottom. There are also generally two low concrete cut-off walls near either edge of the 30-ft. strip which break the continuity of the contact between the rock and the soil core. The rock bottom exposed is generally very irregular and the concrete and the walls are placed so as to best meet the conditions encountered, there frequently being no concrete over high projections of the bottom and the concrete walls being omitted in places where they would serve no useful purpose. Sometimes before and sometimes after placing the concrete, holes are drilled for grouting.

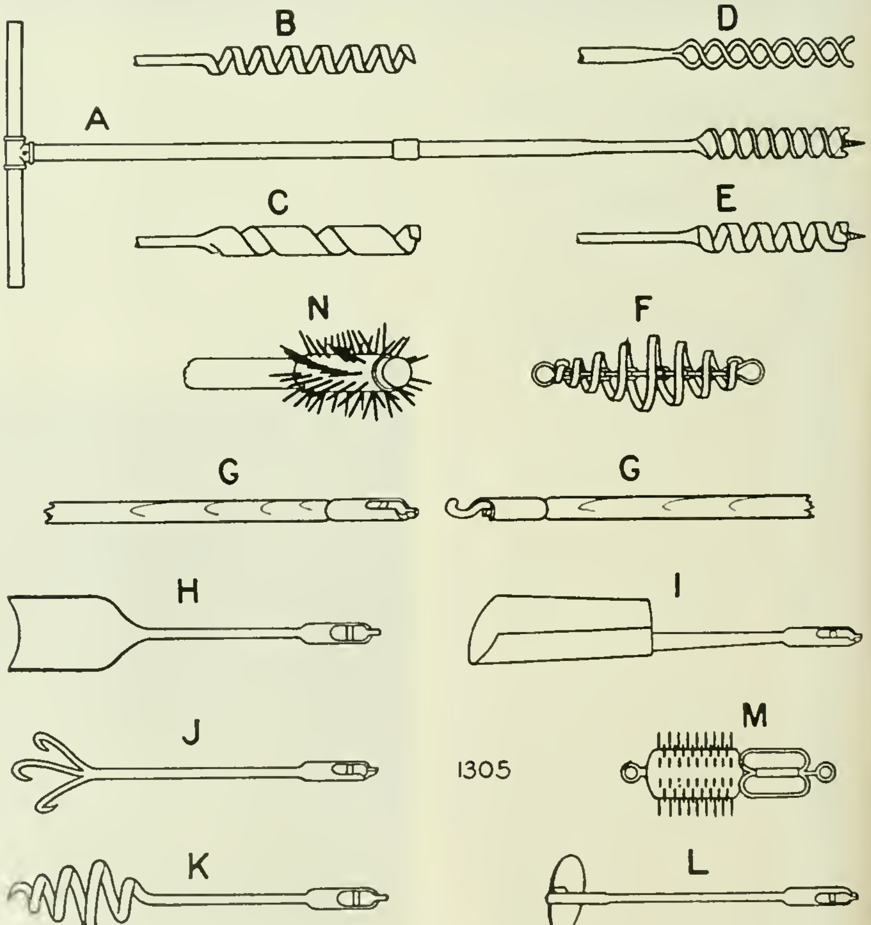
These holes generally do not extend more than 20 ft. into the rock but occasionally holes for test grouting and for other purposes are drilled to considerably greater depths.

Steel pipes with standard couplings, plugs and other fittings are set in the rock or masonry where required so as to give watertight joints to which the grouting machine is connected. The apparatus for mixing and placing grout is mounted on wheels with a direct connected engine, and consists essentially of an air-tight chamber in which the grout is mechanically stirred and from which it is forced by air pressure into the voids. The grout is generally placed under low pressure, much of it at about 5 lbs. to the square inch and little exceeding 20 lb. After a section of the cut-off trench has been grouted, deeper holes, generally 30 to 35 feet in depth are drilled at occasional points to test the completeness of the previous grouting. About half of the foundation for the dam has already been satisfactorily grouted.

4-State Section of Am. W. W. Assoc. Meeting.—There will be a meeting of the "4-State Section" of the American Water Works Association at Baltimore, Nov. 18. C. R. Wood, P. O. Box 363, is Secretary.

House Sewer Cleaning Tools and How to Use Them

Obstructions in house sewers are frequent. Among the causes are broken pipes, grade insufficient to give cleansing velocities, newspaper, rags, garbage, or other solids in sewage, congealing of grease in pipes and main running traps (house sewer traps) and poor joint construction whereby rootlets grow into the sewer and choke it. Where obstruction of a house sewer occurs, use of some of the simple tools shown in the illustration, which is reproduced from Bulletin No. 1227 ("Sewage and Sewerage of Farm Homes") of the U. S. Department of Agriculture, may remedy the trouble.



Tools for Removing Obstructions From House Sewers.

(A) Ordinary 1½ or 2-in. auger welded to a piece of ¾-in. extra-strong wrought pipe about 5 ft. long; the stem is lengthened by adding other pieces of pipe with screw couplings, and is fitted with a pipe handle; all cleaning work should proceed upstream. (B) Twist or open earth auger. (C) Ribbon or closed earth auger. (D) Spiral or coal auger. (E) Ship auger. (F) Root cutter. (G) Sewer rods with hook coupling, usually of hickory or ash 1 or 1¼ in. in diameter and 3 or 4 ft. long. (H) Gouge for cutting obstructions. (1) Scoop for removing sand or similar material. (J) Claw, and (K) Screw for removing paper or rags. (L) Scraper. (M) Wire brush for removing grease, drawn back and forth with a wire or rope. (N) Home-made wire brush (for a 5-in. sewer use a 1½-in. wooden pole to which is securely tacked a piece of heavy rubber, canvas or leather belting or harness leather 5½ by 8 in., spirally studded, as shown, with ordinary wire nails 1½ in. in length).

Observations on Chlorination Tastes and Odors

How They are Caused and Can Be Eliminated Explained in Paper Presented At Last Annual Convention of American Water Works Association

BY WELLINGTON DONALDSON
Of Fuller & McClintock, Consulting Engineers, New York.

Following the court decree of May, 1910, in the well-known Jersey City case, which was generally regarded as establishing the legitimacy of chlorination as a method of water treatment, in so far as it concerned American practice, hypochlorite plants began to be installed for certain supplies experiencing difficulty in conforming to accepted standards for bacterial purity. By 1912 or 1913 the practice of sterilization by hypochlorite had become quite generally established. Later the marketing of successful apparatus for feeding liquid chlorine or chlorine gas gave great impetus to chlorination treatment, resulting in the displacement of many hypochlorite installations by liquid chlorine apparatus and extending in a marvelous manner the utility of this treatment for permanent installations and for emergency and portable use, of which latter the service with the various armies in the war is the outstanding example. Whether or not one agrees with the dictum that no "water supply is safe without chlorination," and the writer personally finds some objections to that phrase, it cannot be disputed that unchlorinaed water supplies derived from surface sources are much in the minority of the United States at the present time. The marked decline in typhoid incidence and mortality in the principal urban communities testifies quite strongly to the wisdom of the practice.

Eliminating Tastes and Odors.

Concurrent with the general adoption of chlorination there began to be noted an annoying prevalence of tastes and odors in many supplies so treated. During the ensuing decade, 1912-22, a great deal has been done towards eliminating tastes and odors although unfortunately at the present time complaints are not infrequent even with some of the larger water supplies kept under very close technical supervision. Many of the troubles of the earlier hypochlorite installations were unquestionably due to lack of adequate devices for feeding the solution at a uniform rate or in proportion to the water treated; to the failure to determine on a routine basis the actual strength of the chemical; or to the failure to make tests for residual chlorine on the treated water. There are today numerous hypochlorite installations 8, 10 or even 12 years old in daily service with satisfactory results both as to sterilization and comparative freedom from tastes and odors, but the considerable supplanting of the older method by liquid chlorine has undoubtedly resulted in elimination of much taste complaint, by reason of the obvious advantages of liquid chlorine in the way of close regulation, uniform strength of chemical, ease of adjustment, etc. Even so, it is by no means rare to find liquid chlorine installations where proper attention is not given to making the doses follow closely the variations in quality of the water treated. It is not surprising, then, that such installations give trouble occasionally on account of overdosing.

Cause of Tastes and Odors.—It is a necessary preliminary to any study of tastes and ordors to ascertain if the taste and odor are found only in the chlorinated water. If taste and odor are found only in chlorinated water their occurrence may be attributed to one or more of the following causes:

(a) Excess or "free" chlorine.

(b) Substitution compounds of chlorine with organic substances.

(c) Killing of organisms with subsequent liberation of aromatic substances, which may or may not unite with chlorine.

With filtration plants delivering direct into the distribution system the last factor may be eliminated.

The taste of chlorine itself, if present in considerable excess, is easy to recognize by comparing with every weak solution of chlorine or bleach. In the writer's experience 0.4 ppm., shown as "residual" chlorine is about the limit of the average person's ability to taste pure chlorine, though some persons with sensitive taste can detect a lesser amount.

The absence of taste after boiling has been suggested as a means of differentiating free chlorine from its substitution compounds but is not entirely reliable as some substitution products are largely removed by a few minutes boiling. The addition of an "anti-chlor" such as sodium thiosulphate, to the sample before testing has been found useful in deciding as to the possibility of free chlorine being a factor. In connection with the possibility of excess chlorine, "chlorine absorption" value advocated by Race, Wohlman and others will be found useful. Many water purification plants control chlorine feeding on the basis of maintaining a fixed "residual" chlorine of 0.1 to 0.3 ppm., in the effluent, the desired amount being determined by experience for that particular supply. The Wohlman method, by reason of establishing a standard dose and standard contact period, has the value of an exact laboratory expression, which makes all results comparable but the writer prefers for practical plant operation the second method, which involves only a simple color test with o-tolidin and the matching against bottle standards.

It is usually the case that odors and tastes are much more pronounced at points on the distribution system than at the purification plant, and it is rare that strong tests for residual chlorine can be gotten from the consumer's faucet, by reason of rapid dissipation of the chlorine in contact with the surface of the iron pipe.

Trouble Due to Substitution Compounds.—If the chlorinated water gives no test for residual chlorine but has a disagreeable taste, it seems prima facie evidence that the trouble is due to "substitution" compounds meaning thereby a combination of chlorine with some organic constituent of the water. Since the early days of chlorination there has been recognized the probability of organic matter combining with chlorine and thus giving rise to disagreeable tastes. The term "organic matter" as applied to water is a very broad term which includes many substances, the nature of which we have little specific knowledge and at present little means of differentiating by laboratory tests.

The responsibility of humus substances from decaying vegetation for production of tastes and odors after chlorination, is not very well defined. There are numerous examples of well managed water supplies located on streams known not to receive any industrial wastes, yet troubled with chlorination tastes and odors. The corelation between the oxygen absorbed tests and chlorine requirement has been fairly well established, but information is lacking as to the effect of high organic matter on production of tastes after chlorination. In fact those supplies with very low organic content seem to experience the greatest trouble.

Taste Due to Presence of Algae.—The writer believes that algae frequently are responsible for mild chlorination taste and recalls an instance where Lyngbya, one of the blue-green algae, when allowed to collect in quantities on the filter beds, gave rise to an unpleasant bitter taste in the water after chlorination. The taste was quite perceptible at the plant though no complaints were reported by consumers. On the other hand, the writer has chlorinated an unfiltered supply heavily infested with diatoms, Cyclotella principally, without appreciably altering the distinct woody" taste present in the unchlorinated water.

The effect of protozoa on production of taste after chlorination, is fresh in the mind in connection with recent experiences of the New York Water Department reported by Mr. Brush in dealing with synura in company with certain diatoms. The remarkable feature of the New York experience was the discovery that while the usual dose of chlorine accentuated the taste and odor from synura, an increased dose eliminated the trouble. The same phenomenon had been previously reported by Girvan and Houston in connection with the New River supply of the London Metropolitan District.

Coal Distillation Wastes.—The increasing pollution of our streams and waterways by industrial wastes has brought to light within the last three years another class of organic substances which affect very greatly the tastes and odors of chlorinated supplies. Principal offenders are the coke by-products plants, city gas plants, producer gas plants and similar industries which discharge spent still liquors or even crude tars. The wastes from coal distillation contain phenol itself but usually its homologs, such as the cresols predominate. All of these substances exhibit a marked tendency to form "substitution" compounds with chlorine even in extremely high dilutions, resulting in a very obnoxious medicinal taste in water supplies. The taste and odor is greatly intensified by heat.

Abundant instances are at hand bearing on the subject. The Milwaukee experiences with obnoxious tastes in its water supply were very clearly traced to the operation of certain coal distillation plants discharging wastes in the river and the lake. The writer has previously recorded an experience with freshly dipped cast iron pipe. Heckmer has presented evidence of the same trouble from use of freshly applied coal tar paint to an elevated water tank. Rowe has most interestingly reported an experience with pipe coating. The evidence is conclusive that the presence of phenols in water results, after chlorination, is greatly intensified and disagreeable tastes and odors. The very numerous sources of phenol pollution to our streams makes the situation from the waterworks standpoint quite serious. So widespread is the trouble from this source, that the writer is tempted to say that where a water supply experiences very disagreeable "medicinal" tastes after chlorination, and tests show the absence of "free" or "residual" chlorine, then the trouble is very apt to be due to the presence in the supply of phenols which may be detected and measured by suitable methods to be discussed below.

Tests for Phenols.—One of the simplest tests for phenol is that largely used in the Milwaukee investigation, namely, of simply adding to the suspected water a few drops of bleach solution and noting if the intense substitution taste occurs, particularly after warming. Such a test may not detect very minute traces of phenol, which, however, may affect the water supply. Usually some concentration method is necessary. In some early investigations at New Castle, Pa., the writer used successfully a method furnished by Prof. Aschmann of Pittsburgh, namely, shaking with ether in a separatory funnel, allowing the ether portion to evaporate and noting the residual odor. Adding to the residue a few cc. of distilled water and a drop of bromine water results in a turbidity or with precipitate of tri-brom-phenol in the presence of appreciable quantities of phenol.

Shaking large volumes of water (1 to 20 liters) with chloroform and evaporating the settled chloroform in a covered dish was found simpler and more sensitive than the foregoing. Addition of a few drops of bleach solution just after the chloroform evaporated produced the characteristic medicinal tri-chloro-phenol odor.

In the New Castle investigations referred to, very interesting results were obtained by freezing at one of the local ice plants 400 lb. cakes from the city water which had at that time a disagreeable medicinal taste. It was found that the cores of the cakes had a very pronounced and unmistakable odor and taste of cresol. The engineer of the ice plant promptly called it a "lysol" odor, which is quite descriptive. On melting the core ice, the cresol odor disappeared and was replaced by a strong woody odor.

Estimating Phenols.—The simple qualitative tests mentioned (though useful in helping decide the nature of the polluting substances, have little or no value for quantitative sudy. E. P. Fager, then chemist of the water company at South Pittsburgh, Pa., in studying in 1919 a variety of methods with a view of quantitative estimation, devised a modification of the Folin-Denis reagent suitable for estimation of phenols in water. The method with slight modification was later used in the New Castle investigation in the winter of 1919-20. Following Mr. Scott's publication of the method, successful results from the method have been reported from a number of laboratories. The Folin-Denis reagent is quite sensitive to phenols (about 0.1 ppm. without distillation), although responsive also to quite a number of other substances, as various observers have noted. The different color reactions, varying from blue to green, are not without value in distinguishing phenol from some of its homologs. The reagent responds also to the higher phenols from the wood distillation industry.

It may be interesting to record here the findings at the New Castle plant that water containing 0.3 ppm. phenol gave rise to noticeable taste after chlorination, which agrees closely with the 0.28 ppm. reported by Ellms as a result of dilution experiments.

In connection with the trouble by some laboratories in getting distilled water blanks for this reagent, the writer calls attention to the fact that distilled water prepared from a water supply containing phenol also. Repeated distillation will not eliminate phenol unless a batch still is used and first portions, containing the bulk of phenols, discarded. The writer has found it much simpler to procure distilled water from a spring or other supply not contaminated with phenols.

Another quite sensitive quantitative test for phenols in water has been proposed by Fox and Gauge, based on the diazo reaction familiar to the organic chemist. Apparently this was used in connection with investigations of the Joint Fisheries Committee in England, as no mention was made of its use in connection with public water supplies. To save the trouble of referring to the English journal in which the article was published the following brief abstract is given:

"Place 100cc of sample in a Nessler jar; add 5cc sodium hydroxide (8%), add 10cc diazotized sulphanilic acid.* On stirring an orange color is formed when tar acids are present.

Distilling 250 to 500cc of sample is advised and if the sample contains turbidity. The author claims a sensitiveness of less than 1 ppm. in comparing with standards prepared by mixing the three cresols in stated proportions. Other observers report a sensitiveness of 0.1 ppm. to pure phenol.

In connection with quantitative determinations of phenols in water, the writer suggests that pure phenol, C_6H_5OH be used as the standard expression for the analysis, whether the actual substance under test be phenol, cresol, quaiacol or some other phenolic substance. Such expression is comparable with the expression of alkalinity, incrustants and hardness in terms of calcium carbonate.

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*The diazotized sulphanilic acid is prepared 5 minutes before use by mixing 5 volumes of sulphanilic acid (1.91 grams in 250cc of distilled water) with one volume sulphuric acid (1 to 3), adding 5 volumes sodium nitrite (0.85 grams in 250cc distilled water) and cooling in a stream of cold water.

Texas Leads in Mileage of Federal-Aid Roads.—Texas leads in miles of completed Federal-aid roads with 1,733 miles. Minnesota is second with 1,416. In mileage of Federal-Aid roads under construction Texas is first with 1,408 miles. Nebraska second with 970 miles, and Iowa third with 945 miles.

Pneumatic Concreting of a Swiss Power Tunnel

In the Swiss Alps a tunnel about 4 miles in length has recently been constructed, for power purposes and has been lined with a lining sufficient to withstand, an internal pressure of 80 lbs. per square inch, and a very heavy external pressure, due to bad rock.

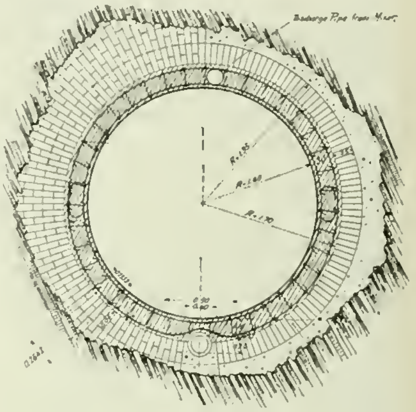

Fig. 1—Cross-Section of Tunnel.

The external pressure was found to be so great especially in places in the tunnel where poor rock were encountered, that a timber lining was found to be insufficient, and was replaced with a brick lining to take the external pressure. Afterwards a reinforced concrete lining was placed inside the brick lining to care for the internal pressure of the water. The accompanying drawings show this cross-section of the tunnel, known as type 7. The concrete for this work was placed by the pneumatic method, the equipment being furnished by the Concrete Mixing & Placing Co., Chicago.

Fig. 2—Cutting Steel for Reinforcing.

Before beginning the concrete work the pneumatic mixers were used for the purpose of transporting the gravel and sand from a point on the side of the mountain, up 500 ft. to the site of

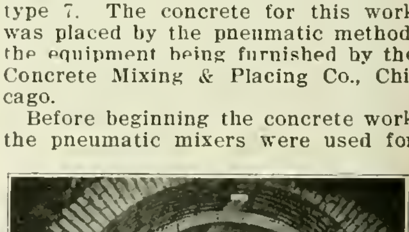

Fig. 3—Steel in Place and Steel Ribs for Forms.

the tunnel. Prior to the adoption of the heavy reinforced inner lining it was intended to make the entire lining of concrete without reinforcement and with a much heavier thickness. But after the test of various types of linings showed it necessary to adopt a lining requiring heavy reinforcing, there was some doubt whether it would be possible to use the pneumatic method. However, it was tried, and at first without success, because the reinforcing intercepted the concrete as it was discharged from the pipe and in falling down over the sides of the arch separated the large stones. Afterwards, however, considerable more sand in proportion to the larger aggregate was used, and the concrete lining was very satisfactory.

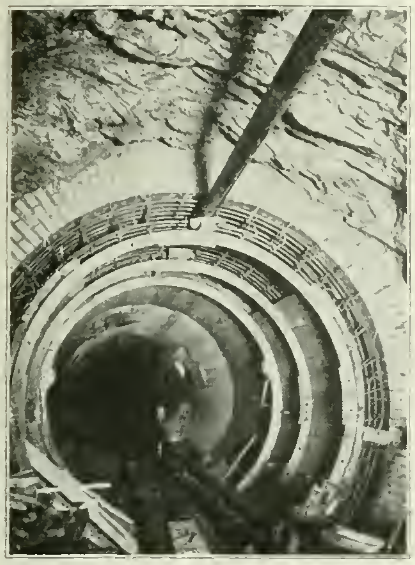

Fig. 4—Section of Tunnel, Showing Bri Lining and Steel Reinforcing and Forn In Place.

The discharge pipe was inserted on the top of the forms, right between the reinforcing as shown in the picture, where there is just enough space for a 6-in. pipe. A 10 ft. section of tunnel was lined at a time. The concrete was discharged on top of the arch, flowing down over the sides until they were filled up to the crown, and then from the back end of the section, in the crown the concrete gradually filled forward to the point where the pipe entered the form.

For this work the pneumatic mixer was mounted on wheels on a 2 ft. gage track and was close to the form, the concrete materials being elevated into the mixer on a short incline track, carrying a large hopper. The steel reinforcing in the tunnel ran 600 Kg. per lineal meter. In Fig. 2, the work of cutting the steel is shown under way. All rods were always half of the arch. In this picture also is shown as a quarter section of the whole arch. Fig. 3 shows the steel in place for the entire circle and also the steel ribs for the forms. Fig. 4 shows the section of the tunnel with the brick lining and steel reinforcing and the forms in place. The concrete pipe for transporting the concrete into the reinforcing is shown at the bottom of the arch. Fig. 5 shows the reinforcing laid in place ready to receive the concrete. This picture also shows the details of the method of tieing the reinforcing.

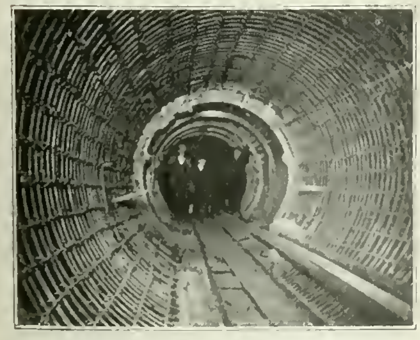

Fig. 5—Reinforcing in Place Ready for Cc crete: Also Shows Method of Tieing Rei forcing.

Mr. Joseph Ruesch, of St. Gallen, Switzerland, was the contractor for the work.

Why It Pays to Beautify Water Works Grounds

Abstract of a Paper Presented Sept. 16 Before Convention Southwest Water Works Association

By R. E. M'DONNELL,
Of Burns & McDonnell, Consulting Engineers, Kansas City, Mo.

It is almost impossible to overdress or overdo the beautifying of waterworks grounds. Your first impression of a water plant, like your first impression of an individual, is gained from appearances and may be favorable or unfavorable. The water plant does not exist or succeed that can afford to ignore public opinion. Without favorable opinion, it is almost impossible to make 100 per cent collections, difficult to enforce regulations, and useless to attempt the raising of funds for extensions or rehabilitation.

Out of approximately 6,000 water plants in the United States, it is a safe estimate that half of them have no ornamentation or artistic treatment of the grounds and the appearances are such that public opinon is unfavorable concerning the works. About 80 per cent of all water expenditures are for wells, mains, conduits, services, meters, and other underground structures, consequently, the buildings and grounds constitute a relatively small expenditure in comparison with their importance from the standpoint of the visitor. The entire water plant is judged by the appearance of that part visible to the layman.

Park on Grounds of Water Works Department of St. Louis, Mo.

If the grounds are clean, well kept, artistic, and pleasing to the eye, the whole plant instantly receives favorable approval. The money spent in beautification of the grounds is a wise expenditure and a good advertisement for the entire city, for cities are judged by their water supplies. The health record of a city is an indication of the kind of water supply it has.

The safety and purity of a water supply is often judged by the external appearance of the reservoirs and surroundings. A feeling of security of health is assured when buildings and grounds are immaculate in appearance. Even the smallest plant can afford a few flower beds, shrubbery, and perhaps a little pool or fountain. I sometimes think women would make better water officials than men, their artistic temperament is more highly developed and they would at least apply their good house-keeping principles to the grounds and station.

Some cities have either located their stations in city parks, or park departments have taken over the grounds as a part of the park work. South Bend, Ind., has its principal station in Riverside Park and the architecture of the buildings and character of improvements were designed in keeping with the surroundings. The St. Louis water works surroundings are very elaborate, consisting of fountains, pools, shaded paths, and beautiful drives, making it one of the show places of our larger American cities. Rochester, N. Y., has in its water reservoir a fountain that adds to that city's fame and reputation and is long remembered by visitors. Our ancient aqueducts, with their graceful vine-covered arches, were structures of beauty, but with the advent of pumping machinery and pipe lines in their places, we are not seeing as many pleasing water structures as formerly existed.

No one ever questions the wisdom of this expenditure for beautification. It pays for the small town as well as the large city. It is good advertising and good business for the superintendent, the mayor, the water board, and the city and it does the consulting engineer no harm to leave his job with an attractive appearance, as well as an efficient works.

Co-operation of Water and Fire Departments

Abstract of a Paper Presented at the Annual Meeting of the Illinois Section of the American Water Works Association

BY CLARENCE GOLDSMITH,
Assistant Chief Engineer, National Board of Fire Underwriters, Chicago.

The general requirements which are imposed upon water works systems for adequate and reliable fire service are in main standardized and well understood by water works engineers and superintendents. In order that all the facilities available in both the water and fire departments may function up to as nearly 100 per cent of their ability and capacity during the progress of a fire, it is necessary that the two departments combine their efforts in harmonious action. If this is to be brought about, the heads of each department should make a thorough study together of the many conditions which might arise and formulate definite plans to secure the maximum unity in operation before the fire or emergency occurs.

How the Water Department Men Can Help.—Alarms of fire should sound in some quarters of the water department and a responsible employee familiar with the system should respond to fire alarms in mercantile districts and second alarms elsewhere. An emergency motor-driven truck loaded with necessary tools should be provided for general emergency work and can be used for response to fires as well.

The value of such response should not be underestimated, and it is equally important in small as well as large cities. In the smaller places the fire department may be mainly or wholly composed of call men or volunteers and frequently, because of lack of training, they do not understand operating the hydrants. For instance, a water works man can readily place a wrench on a hydrant outlet cap which is stuck and with a sharp kick start the cap, while one inexperienced in such cases could not remove the cap. Cases have been known where firemen did not know in which direction to turn the hydrant stem nut to open the hydrant and broke the stem off by trying to turn it in the wrong direction, and many times it has been found that the foot valve or independent valve on a hose outlet has not been opened wide in cases where it was claimed that sufficient pressure at the nozzle or sufficient suction supply to the pumper or steamer was not available. Such a case can be promptly corrected by a water works man, provided he is present.

In cases where large service connections enter the building, which is on fire, and these connections serve only domestic and process water, they should be shut off immediately. If such connections serve standpipes or automatic sprinkler equipment, the water works representative should find the valve box in the street or sidewalk which controls the connection and be prepared to close the valve in case the chief of the fire department finds that the inside piping system has failed and undue quantities of water are being delivered into the building and not being delivered on the fire, but it should always be remembered that sprinkler heads operating in the area involved by the fire are delivering water onto the seat of the fire to better advantage than can ordinarily be done by hose streams.

The chief of the fire department should ascertain from the water department the approximate quantity of water which the distribution system can deliver into each sprinkler equipment at a pressure sufficient to effectively operate the sprinkler heads at the highest elevation. If this knowledge has been obtained, it will be possible for the fire department to increase the supply where deficient by connecting hose lines from pumpers to the steamer connections of the sprinkler equipment, provided for this purpose; in any case, the rules of the department should require the second hose line laid to be connected to the steamer connection.

Transmitting Fire Alarms to Pumping Stations.—Alarms should sound in pumping stations of direct pumping system where pressures are raised to furnish hydrant streams or pumpers are started to furnish fire service, duplicate alarm circuits should be provided, as to fire stations. In cities and towns having no fire alarm telegraph systems dependence has to be placed on the telephone, but this means of transmitting alarms cannot be considered as satisfactory as alarm circuits of the fire alarm system.

In water systems supplied by direct pumpage, it is generally necessary to start additional pumps in case any considerable water is required to extinguish a fire. In small cities and towns the fire flow rate required is considerably in excess of the domestic consumption rate. In a city having 17,000 population, the average domestic consumption rate may be about 1,700,000 gal., but the required fire flow rate is 5,760,000 gal. It is readily seen that under such circumstances it is necessary to increase the rate of pumpage for fires of even moderate proportions. In order to increase the supply promptly upon receipt of an alarm of fire, it is necessary to be able to force the boilers in service and have a sufficient boiler capacity under one-half steam to start additional pumps.

In this connection plans should be made to make major repairs to pumping units during the seasons of the year when domestic demands are at the minimum so as to maintain as large a pumping capacity in service as possible, taken in relation to the combined fire and domestic demands.

Where pressures are raised for fires, this question assumes greater importance for the prevailing domestic rate increases somewhat as the pressure is increased. Wherever direct hydrant hose streams are available, it is advisable for the fire department to provide relief valves for each hose line so that when shut-off nozzles are used the possibility of producing damage by a water ram may be obviated.

Maps of Distribution System and Hydrant Inspection.—Each fire station should be provided with a map of the water distribution system showing the size of the mains and the location of the hydrants. All firemen should be intimately acquainted with the location of hydrants, particularly in their districts. Commanding officers should have a general knowledge of the sizes of mains so that proper advantage may be taken when two hydrants are equally available and one is supplied from a large main and one from a small main.

Hydrants should be inspected in the Spring and Fall of each year. The inspection should include the flushing of the hydrant which will test its operation, greasing the hydrant caps, all of which should be removed, and oiling the packing if it needs it. Before the caps are replaced, it should be ascertained that the drain is operative.

There should be enough hydrants installed so that the water required can be concentrated on any group of buildings through hose lines, none of which shall exceed 500 ft. in length. Whether the protection is dependent on pumpers or direct hydrant streams, every effort should be made to cut down the friction loss in hose lines.

How the Superintendent Can Assist.—The water works superintendent or engineer is frequently better versed in handling hydraulic problems than the chief of the fire department, and for this reason, he may be of great assistance along this line. For instance, the question of the friction loss in fire hose can be determined by the following approximate formula: The loss per 100 ft. in 2½-in. rubber-lined fire hose in pounds is equal to 2 q.^{2} plus 2., where q. is the quantity in 100 gal. The discharge in gallons through nozzles of different sizes when attached to different lengths of hose for the ordinary range of engine and hydrant pressure is given in tables contained in the "Red Book" published by the National Board of Fire Underwriters.

Another problem which frequently comes up in connection with hose streams is that of the reaction or pull-back of the play-pipe under varying conditions of pressure and size of tips. The pull-back in pounds is 1.5xd^{2}xp. where d. is the diameter of the nozzle in inches and p. is the pressure at the base of the play-pipe.

Advantages of Co-operation.—A few examples of the advantages of co-operation between fire and water departments may not be out of place. In one of our larger cities the fire department had great difficulty in getting horse-drawn steamers up a steep hill, although the hose wagons were generally able to negotiate the run, even with snow and ice on the ground. At the top of this hill there had formerly been a reservoir which was served by a 24-in. line. The reservoir had been abandoned and the large main ordinarily carried about 28 lb. pressure, but the fire department had been waiting until the engines arrived before attempting to get hose streams on fires. The major portion of the buildings were 3-story frame structures which burned rapidly. A conference was held between the engineer of the water works and the chief of the fire department, which resulted in having two hose wagons go to the top of the hill and it was shown that by the use of ¾-in. tips on the shut-off nozzles that fairly effective fire streams could be thrown without the use of engines.

Weak places in distribution systems and dead ends occur in most every distribution system. In such cases where direct hydrant hose streams are depended upon it very frequently occurs that the fire department lays out so many lines that none of the hose streams are effective. All such phases should be considered in conference and the fire chief informed of the approximate number of effective streams which can be used at each location.

The water department should have a sample hydrant available so that members of the fire department may be instructed in regard to the mechanical operation of the hydrant, for without such knowledge much serious abuse of hydrants is liable to occur.

Adequate Pressures Required.—Adequate pressures are necessary to furnish the service required. Where fire engines are used, sufficient pressure must be maintained in the mains to overcome the friction loss in the hydrant branches and hydrants and to provide sufficient velocity head to get the required water to the steamer or pumper. Ordinarily 20 lb. in the mains when the maximum fire draft is being drawn is sufficient.

There has been a tendency during the past few years, because of the necessity of inaugurating all economies in operation, to reduce pressures on water distribution systems at night. Care should be taken not to reduce pressures to such an extent that existing sprinkler equipments cannot receive a proper supply on the upper lines of sprinkler heads. Even where pumpers are used to develop the hose streams, it is important to maintain a moderately high pressure on the mains.

The rated capacity of pumpers is based upon a discharge pressure of 120 lb. and where long lines of hose are needed, it is necessary to carry higher discharge pressures, which result in reducing the rated capacity of the pumper, for a pumper will only deliver about one-half its rated capacity at 200 lb. discharge pressure, and only about one-third its rated capacity at 250 lb. pressure. It is readily seen that if 220 lb. discharge pressure were required, and a suction pressure of 100 lb. could be maintained, the pumper could deliver its full rated capacity under these conditions, whereas if the suction pressure were reduced to zero, the capacity of the pumper would be reduced by about one-half.

Inspectors Wanted by Government.—The U. S. Civil Service Commission states it will receive applications until Dec. 5 to fill positions of inspector (mechanical) at the Naval Station, Pearl Harbor, T. H. The pay offered is $7.20 a day with an additional allowance of 96 cts. a day while employed at the station. Transportation is furnished by the Government. Competitors will not report for a written examination, but will be rated upon the subjects of technical education and preliminary experience (30 per cent) and special experience and fitness (70 per cent). A degree in mechanical or electrical engineering from a recognized college or university and at least three years of certain specified experience are required, except that seven years of experience in mechanical engineering will be accepted in lieu of a college course.

Philadelphia Contracts for 60,000 Ft. 1¼ in. C. I. Pipe.—The city of Philadelphia has awarded a contract to the McWane Cast Iron Pipe Co. for 60,000 ft. of 1¼ in. cast iron pipe for use in its Torresdale filtration plant. The pipe is the McWane precalked joint type. The order will be filled from the McWane Co.'s leased plant in North Birmingham, as its new East Birmingham plant will not be completed until March 1.

The Sewage Treatment Problem in the United States from the Standpoint of Sludge

Conditions existing in the sewage treatment works of cities of the United States with populations of 25,000 upward, summarized in a progress report presented Oct. 5 to the American Society of Municipal Improvements by the general Committee on Sewerage and Sanitation, of which Langdon Pease is Chairman. The data for this report, which is printed below practically in full, were compiled from a questionnaire sent out to over 700 cities and towns.

Population and Number of Sewage Treatment Works.—The 1920 census figures give the following number of incorporated municipalities having the population indicated or more:

No. of Cities.	Population in 1920 — Limit.	Population in 1920 — Total.
68	100,000 and up.	27,429,326
219	25,000—100,000	10,340,738
2500	2,500— 25,000	16,534,489

Of these cities those having sewage disposal works have been listed, and also those with works under construction in each group.

The populations of the cities with

TABLE I.—GENERAL DATA CITIES OF 100,000 AND UP.

City.	Population 1920 Census.	Percent Sewered to Treatment Works.	Sewers.	No. of Treatment Plants. In Use.	No. of Treatment Plants. Proposed.
Philadelphia	1,823,779	0.2	C	1	1
Cleveland	796,841	78.0	C	2	..
Baltimore	733,826	73.0	S	1	..
Rochester	295,750	87	C, S[4]	3	..
Providence	237,595	98	C	1	..
Columbus	237,031	..	C	1	..
Akron	208,435	25—30	C	1	..
Atlanta	200,616	..	C	3	..
Worcester	179,754	90—95[1]	C, S[1]	1	..
San Antonio	161,379	..		1	..
Dallas	158,976	80+	S	1	..
Bridgeport	143,555	..		1	..
Houston	138,276	70[3]	S[2]	2	..
Albany	113,344	92	C	1	..
Reading, Pa.	107,784	..	S	1	..
San. Dist. of Chicago.	2,986,000	5.5	C	3	5
Birmingham	178,806	85.4	S	2	..

[1] In 1922, 69.813 miles combined, 117.169 miles separate.

[2] Very small amount of combined sewers.

[3] All night soil dumped into sewers reaching Treatment Works.

[4] Irondequoit Plant served by combined sewers. C—Combined. S—Separate.

TABLE II.—PLANT DATA, CITIES OF 100,000 AND UP.

	Area Provided, Acres.	Type of Plant — Screen.	Type of Plant — Tank.	Type of Plant — Filter.
San. Dis. of Chicago—				
Desplaines	26.52	Bar & Fine, G	Activated	Sludge
Morton Grove	1.25		Imhoff	Trickling
Calumet	106.4	Bar, G	Imhoff	....
Philadelphia—				
Pennypack Creek	6	Bar	Imhoff	Trickling
Cleveland—				
Westerly	.....	Bar, G	Imhoff	....
Easterly	.....	Bar, G		....
Baltimore	468.08	Bar	Hydrolytic	Trickling
Rochester—				
Irondequoit	315	Bar & Fine, G	Imhoff	....
Brighton	22	Bar, G	Imhoff	Trickling
Charlotte	0.7	Bar, G	Imhoff	....
Providence	.....	Bar	Chemical	Precipitation
Columbus	30	Bar	Imhoff	Trickling
Akron	60	Bar, G	Imhoff	Trickling
Atlanta—				
Proctor Creek	19	Bar, G	Imhoff	Trickling
Intrenchment Creek	30	Bar, G	Imhoff	Trickling
Peachtree Creek	116.5	Bar, G	Imhoff	Trickling
Worcester	100	Bar, G	Chem. Proc. Sedimentation	
Birmingham—				
Valley Creek	.....	....	Septic	Contract
Ensley	.....	....	Sedimentation	
San Antonio	.....	——— Irrigation by Contract ———		
Dallas	100	Bar, G	Imhoff	....
Bridgeport	.....	Fine Screen	....	....
Houston—				
North Side	3	Bar, G	——— Activated Sludge ———	
South Side	1.5	Bar	——— Activated Sludge ———	
Albany	.....	Bar, G	Imhoff	....
Reading	.....	....	Septic	Trickling

Note.—"G" under Screen column indicates Grit Chamber.

TABLE III.—ENGINEERING DATA, CITIES 100,000 AND UP.

City.	Water Use, Gal. per Cap.	Sewage Treated, Mil. Gal. 24 Hours. Avg.	Sewage Treated, Mil. Gal. 24 Hours. Max.	Susp. Matter P. P. M. Raw.	Susp. Matter P. P. M. Ap. to Fltrs.
Philadelphia—					
Pennypack Creek	200	[1]1.25	2	60	30
Cleveland	.....	.....	.....	...	.....
Baltimore	.....	46.6	66.6	252	75
Rochester	90	.....	.....	...	.....
Irondequoit	.....	32.6	66.2	173	82
Brighton	.....	1.18	1.86	150	29.4
Charlotte	.....	0.27	0.56	460	149
Providence	79.5	.....	.....	...	.....
Columbus	86	22.6	36	218	108
Akron	[2]90 to 100	8	.15	...	.....
Atlanta	90	.....	.....	...	.....
Procter Creek	.....	.....	.....	328	46
Intrenchment Creek	.....	.....	.....	140	44
Peachtree Creek	.	.....	.....	145	59
Worcester	83.5	21.2	48.9	174[3]	....
San Antonio	.....	....	.....	...	....
Dallas	.....	6.3	.....	...	....
Bridgeport	.....	.....	.....	...	.....
Houston	70	.....	.....	...	....
North Side	.....	6	9	(4)	....
South Side	.....	1.8	2.5	200	....
Albany	.....	14.3	19.9	...	.....
Reading	.....	6.2	.....	132	96

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[1] Average 9 years.

[2] 25 to 30 per cent of population is treated.

[3] Day 278 p. p. m., night 151, effluent plain sedimentation 200 p. p. m.

[4] P. P. M. in 1920, 174; 1921, 342; 1922 to May 19, 542.

TABLE IV.—AMOUNT OF SCREENINGS AND GRIT, CITIES 100,000 AND UP.

City.	Screen Openings, Inches.	Screenings, Cu. Ft. per Mil. Gal.	Grit, Cu. Ft. per Mil. Gal.
Philadelphia—			
Pennypack Creek	¾	4(a)	2
Cleveland—			
Westerly			
Easterly			
Baltimore	1	3.25(e)	
Rochester—			
Irondequoit	3, 1/16x2, ⅛x2	5.17(b)	1.81 + 1.90(x)
Brighton	11/16	5.17(a)	0.73
Charlotte	11/16	(a)	
Providence	3	(ad)	
Columbus	1, ½	1 to 2(d)	1.7
Akron	2	0.15(a)	9
Atlanta—		(a)	
Procter Creek	1½		5.4
Intrenchment Creek	C. to C.		to
Peachtree Creek			16.2
Worcester			2.7
Dallas			
Bridgeport			
Houston—			
North Side	1	3.25 ac	
South Side	1	2.93ac	
Albany		0.21	3.0
Reading		(y) (c)	
San. Dist. of Chicago—			
Desplaines	1, 1/16 x 2		
Calumet	1		

(a) Buried. (b) Dumped. (c) Burned. (d) Spread on land. (e) Sold to farmers. (x) 1.81 at plant. 1.90 before reaching plant. (y) 365 lb. per mil. gal.

TABLE V.—SLUDGE DATA, IMHOFF TANKS, CITIES 100,000 AND UP.

	Liquid Sludge			
City.	Cu. yd. per mil. gal.	Cu. yd. per year.	No. Air Dryings per year.	Moisture per cent on removal trom beds.
Philadelphia—				
Pennypack Creek	0.8	328[1]	3	
Baltimore				
Rochester—				
Irondequoit	2.5[2]	29,701	13	49 to 62
Brighton	1.03	444	6	56
Charlotte				
Columbus	11.5	45,000	6	30 to 40
Atlanta—				
Proctor Creek			every	15
Intrenchment Creek			two	to
Peachtree Creek			weeks	25
Worcester	6.95			
Dallas			every week	
Albany	1 06			

[1] Nine year average. [2] The amount drawn corrected for storage gives the 1921 accumulation as 1.45 per mil. gal. and 17,329 c. y. for year.

sewage treatment works are as follows:

	With Sewage Treatment Works		
Group.	No. of Cities.	Pop. of Cities.	% of Ttl. Group.
100,000 and up	17	8,701,747	31.7
25,000 to 100,000	26	1,232,993	11.9

The population of the cities having sewage works under construction are as follows:

	Sewage Treatment Works Under Construction		
Group.	No. of Cities.	Pop. of Cities.	% of Ttl. Group.
100,000 and up	3	943,058	3.4
25,000 to 100,000	2	71,709	0.7

The data collected have been general, as well as applied to the sludge problem. For all cities over 25,000 the data have been tabulated, divided into the two groups.

Data for Group 100,000 and Up.—Tables I, II and III show the data, classified hy general plant and engineering for the group over 100,000. Most of the cities have combined sewer systems. Tables IV and V show the data on amount of screenings and grit, and on sludge from Imhoff tanks. Table VI gives data on miscellaneous sludges.

TABLE VI.—SLUDGE DATA, MISCELLANEOUS CITIES, 100,000 AND UP.

	Liquid Sludge.			
Cities.	Cu. yd. per mil. gal.	Cu. yd. per year.	No. Air Dryings per yr.	Moisture per cent on removal from beds.
Settling or Septic Tank—				
Baltimore[1]	6.39	107,400	3¾	68.7
Reading	2.9	......	...	....
Chemical Precipitation—				
Providence	11.17	116,564	...	([2])
Worcester	18.9	121,000	...	...

[1] Based on 6 year average. [2] Sludge when filter pressed has 30 per cent moisture.

TABLE VII.—SLUDGE DISPOSAL, CITIES 100,000 AND UP.

	Dump at sea	Lagoon.	Air dry and dump.	Run out and plow in.	Into stream at flood.	Dry.
Philadelphia	...	...	*	...	...	...
Cleveland[3]	*	...	...	...	...	...
Baltimore	...	...	*	...	...	*
Rochester	...	...	*	...	...	...
Providence	*	...	...	...	...	...
Columbus	...	*	*	...	*	...
Akron	...	...	*	...	[2]*	...
Atlanta	...	...	*	*	*	...
Worcester[1]	...	*	...	...	...	...
San Antonio	...	*	...	...	...	...
Dallas	...	...	*	...	...	...
Bridgeport	...	...	...	...	...	...
Houston	...	*	...	...	*	*
Albany	...	...	*	...	...	...
Reading	...	*	...	...	...	...

[1] No money appropriated to operate sludge presses since April, 1917. [2] Major portion of sludge discharged into river. [3] Dumped into Lake Erie.

The inquiry also shows that in the operation of the plants with the exception of Baltimore, practically no complaints are found, either on the plant itself or the sludge disposal.

Table VII shows the methods of sludge disposal. With the exception of Cleveland and Providence, practically all of the cities making air dried sludge dump it on land. Cleveland dumps liquid sludge in Lake Erie. Providence dumps liquid sludge at sea. Five cities lagoon sludge. One plows some liquid sludge into the ground. Four discharge sludge at flood in the river, as opportunity offers. Two have actually tried heat drying.

Table VIII shows the use of the sludge by farmers. Three cities report no use. Seven cities report some use. Of these six say that the same farmer may call for sludge year after year. Only three report any receipts for the sludge and then only nominal amounts.

The sludge analyses reported (Table IX) Imhoff or settling on the tanks all show low nitrogen, ranging from 1.25 to 3.3 per cent on a dry basis. The ether soluble ranges from 4.6 to 20 per cent. The activated sludges reported (Table X) have a much higher nitrogen content.

Data for Group 25,000 to 100,000.—Tables XI, XII and XIII show the data, classified hy general, plant and engineering for the group under 100,000. Most of the cities have separate

TABLE VIII.—SLUDGE USE, CITIES 100,000 AND UP.

City	Hauled by Farmers.	Used Year after Year.	Money Received.
Philadelphia[1]	Yes	Yes	No
Baltimore[2]	Yes	Some do and	25c per load
Rochester	Yes	some don't	75c load 2 c. y.
Providence	Small amount	Yes	No
Columbus	Yes.	No	No
Akron		Yes	
Atlanta	Yes		Contract
Worcester	Some	Yes	No
Dallas	No	Some	
Bridgeport			
Houston	No		
Albany	No		
Reading	(?)		

[1] Nine year average. [2] Received from $374.47 to $2,689.94 per year from farmers and from sale to fertilizer company.

TABLE IX.—SLUDGE ANALYSIS AS REPORTED FOR IMHOFF AND OTHER TANKS, CITIES 100,000 AND UP.

			Per Cent. Dry Basis			
City.	Sp. Gr.	H_2O.	Volatile.	Fixed.	Nitrogen.	Ether Soluble.
Philadelphia—						
Pennypack Creek	1.065	85	41	59	....	20
Baltimore[1]	1.020	91.6	74	26	2.64	9
Rochester—						
Irondequoit	1.025	89	44	56	1.95	6.0
Brighton	1.03	81.2	35	65	1.82	8.4
Charlotte	1.02	84	41	59	1.7	7.1
Columbus	1.02	....	....	....	1.2	....
Akron	....	....	....	....	....	....
Atlanta	1.02	....	39	61	1.25	6.1
Worcester[2]	1.06	91.9	46	54	3.3	4.6
Dallas	....	....	....	....	....	....
Albany	1.04	86.1	45.9	54.1	1.6	6.5

[1] Hydrolytic. [2] Experimental.

TABLE X.—SLUDGE ANALYSIS AS REPORTED, ACTIVATED SLUDGE, CITIES 100,000 AND UP.

		Per Cent. Dry Basis				
Place.	Sp. Gr.	H_2O.	Vol.	Fixed.	N.	Eth. Sol.
Worcester*	1.01	98.06	51 to 74	26 to 49	3.2 to 7.35	1.9 to 9.0
Houston	1.06	99.6	59 to 70	41 to 30	...	10

*Experimental.

TABLE XI.—GENERAL DATA, CITIES 25,000 TO 100,000.

City.	Census, 1920.	Per Cent. Sewered to Treatment.	Sewers.	No. of Treatment Plants. Proposed.	In Use.
Schenectady	88,723	50	S	1	..
Canton, Ohio	87,091	80	S	1	..
Allentown	73,502	?	..	1	..
Brockton	66,254	95	S	1	..
Pawtucket	64,248	..	..	(1)	..
New Britain	59,316	80	S	1	..
Long Beach	55,593	75	S	1	..
Atlantic City	50,707	..	..	..	..
Jackson, Mich.	48,374	..	..	1	..
York, Pa.	47,512	33	S	1	..
Fresno	45,086	100	S	1	..
Mt. Vernon	42,726	..	S	1	..
Lakewood	41,732	77[3]	(4)	1	..
Woonsocket	43,496	75	S	1	..
Lexington, Ky.	41,534	..	C	1	..
Fitchburg	41,029	93	(2)	1	..
Stockton	40,296	100	S	2	..
Springfield, Mo.	39,631	..	?	1	..
Madison	38,378	100	S	1	..
Stamford	35,096	..	..	..	..
Austin	34,876	80	S	1	..
Pontiac, Mich.	34,273	90	S	1	..
Colorado Springs	30,105	..	..	..	..
Marion	27,891	..	..	1	1
Mansfield	27,824	90	S	1	..
Plainfield	27,700	100	S	1	..

[1]Portion of sewage direct to Blackstone R., portion to works of Providence, R. I. [2]Sewers 70 per cent combined, 30 per cent separate. [3]23 per cent is handled by Cleveland. [4]23 per cent of sewer system is combined, 77 per cent separate.

TABLE XII.—PLANT DATA, CITIES 25,000 TO 100,000.

City.	Area Provided in Acres.	Type of Plant Screen.	Type of Plant Tank.	Type of Plant Filter.
Schenectady	22	Bar	Imhoff	Trickling
Canton	25	Bar	Imhoff	Contact
Allentown	0.57	Mesh	Electrolytic	
Brockton	170	Bar	Settling	37 ac. Sand
New Britain	90	Slot	....	2 ac. Trickling
Long Beach	...	Slot	....	....
Atlantic City	...	....	....	....
Jackson	...	....	....	....
York	27	Bar	Imhoff	....
Fresno	800	... .	Septic	....
Mt. Vernon	...	....	Settling	Farm
Lakewood	10	Bar, G	Imhoff	Trickling
Woonsocket	...	Bar	....	....
Lexington	...	Bar	Imhoff	Sand
Fitchburg	120	Bar	Imhoff	Trickling
Stockton—				Trickling
North	0.5	R. W.	Chlorination	
South	...	....	Imhoff (Chlorination)	
Springfield	...	....	Imhoff	
Madison	40	Bar	Sep. Digestion	Trickling
Stamford	...	....	....	Trickling
Austin	20	Bar	Imhoff	....
Pontiac	16	Bar	Imhoff	Trickling
Mansfield	...	....	Imhoff & Sept.	Contact
Plainfield	92	Slot	Imhoff	Trickling

TABLE XIII.—ENGINEERING DATA, CITIES 25,000 TO 100,000.

City.	Water Use, Gals. per Cap.	Sewage Treated, Mil. Gal. per 24 Hr. Average.	Sewage Treated, Mil. Gal. per 24 Hr. Maximum.	Susp. Matter P. P. M. Raw.	Susp. Matter P. P. M. Apl. to Fltr.
Schenectady	158	6	9	146	34
Canton	...	5.56	10.02	268	92
Allentown	96 to 192	....	.....	...	..
Brockton	44	2.75	6	206	97
New Britain	70	4	.....	129	..
Long Beach	45	3.5	4.75	...	..
Atlantic City	...	....	.....	...	..
Jackson	...	....	.....	...	..
York	85 to 90	2.75	4	110	50
Fresno	300	8	.....	...	..
Mt. Vernon	...	....	.....	...	..
Lakewood	90	4	6	...	..
Woonsocket	56	1.5	.....	171	..
Lexington, Ky.	...	3	.....	...	..
Fitchburg	100	2.4	10	389	60
Stockton	135	....	.....	...	..
North	...	1.8	2.95	...	..
South	...	....	.....	...	..
Springfield, Mo.	...	....	.....	...	..
Madison	100	5.7	10	299	98
Stamford	...	....	.....	...	..
Austin	...	2.5	4.5	...	..
Pontiac	110	3.8	6.5	200	5
Marion	...	....	.....	...	..
Mansfield	...	2.5	.....	...	..
Plainfield	100	3.5	4.5	150	60 to 70

sewer systems. Tables XIV and XV show the data on amount of screenings and grit, and on the sludge from Imhoff tanks. Table XVI shows sludge data for miscellaneous plants.

The inquiry also shows that in the operation of the plants with the exception of Schenectady, New Britain, Fresno, Austin (before covering tanks and trapping sewer outlet) and Plainfield practically no complaints are reported either on the plant itself or sludge disposal.

Table XVII shows the methods of sludge disposal with the exception of Madison, which lagoons, and Fresno, Mansfield and Plainfield which run sludge out into the fields and plow in. Practically all the cities having air dried sludge dump it on land. One city discharges at flood into the river. None have tried heat drying.

Table XVIII shows the use of the sludge by farmers. Eight report no use. Seven report some use. Of these six, five say the same farmer may call for sludge year after year, but one notes that the sludge is not used on the same land. Only one city reports any receipts for sludge, and that only $2 per cubic yard. This is the highest rate of sale reported.

The sludge analyses reported on (Table XIX) the Imhoff and settling tanks all show low nitrogen, ranging from 1.21 to 2.6 per cent on a dry basis. The ether soluble content ranges from 2 to 7.5 per cent on a dry basis. The electrolytic sludge from Allentown is very low in nitrogen, because of the lime used, and is even higher in fixed solids than the Worcester sludge (Table XX).

Comparative Analyses. — Through the courtesy of Mr. H. P. Ramey, Acting Chief Engineer, The Sanitary District of Chicago, and Dr. F. W. Mohlman, Chemist, the committee presents Table XX, showing analyses of typical sludges, shipped in from the various plants shown, and analyzed in the laboratory of the Sanitary District. This table shows more clearly the variation of nitrogen content in the different types of sludge. The activated sludge of the Corn Products Refining Co. testing station at Argo shows up the highest, with the domestic activated sludges next in amount.

Operating Data.—The results of the inquiry show that the plants in the cities of 100,000 and upwards in general have technical attention and in most cases a chemist in charge, even though money is not always available for continued or complete operation. In the cities from 25,000 to 100,000 only 6 have any complete control. Among the most thoroughly operated appear Fitchburg and Plainfield. The rest may have some control by a city official, but not enough to keep any real operating data. One city frankly reports no funds.

Sludge Disposal.—From the standpoint of sludge disposal and use, the very great preponderance of air drying and dumping as a means of disposal is of note. Further, the lack of interest by farmers and the general lack of income as yet from sludge disposal are noteworthy. For this the low nitrogen content generally prevalent may be responsible. However, there is the possibility of lack of publicity. With suitable publicity one of the smaller towns within 40 miles of Chicago has been selling its Imhoff sludge for several years at $5 per load. Chemical precipitation sludge appears to have practically no value.

Steps Necessary.—The obvious step necessary to interest the farmer in sludge is the development of a real yardstick of value. For this end the need of intelligent treatment on experimental farms is urged. At the suggestion of Mr. Hatton, the Secretary of the U. S. Department of Agriculture has been requested by various municipalities to allocate part of the budget of his department for a thorough investigation trying sludges in different parts of the country and in different crops. The experiment stations of the state of Illinois and Wisconsin have been urged by the Sanitary District of Chicago and the Milwaukee Sewerage Commission to cooperate. They have expressed a desire to do so within the limits of their resources. Further, the Sanitary District of Chicago is planning to undertake some experimental work in the vicinity of the truck farms around Chicago.

In order to determine all the elements of value trials extending over several years will be needed. Such trials to be effective necessarily must be quantitative. To properly apply the fertilizer and learn its true value, such trials should be under the direction of trained agricultural experts who know what fertilizers and what amounts are requisite for the different trial crops. Dr. Schreiner of the Bureau of Soil Fertility of the U. S.

TABLE XIV.—AMOUNT OF SCREENINGS AND GRIT, CITIES 25,000 TO 100,000.

City.	Screen Openings, Inches.	Screenings, Cu. Ft. per Mil. Gal.	Grit, Cu. Ft. per Mil. Gal.
Schenectady	1½	(a)	....
Canton	1 or ¾	4.02(c)	0.22
Allentown	¼ mash	9.9(ac)	4
Brockton	1¼	(a)	....
New Britain	1/16 x ½	30(d)	....
Long Beach	1/32 x 2	(c)	....
Atlantic City	....	....	....
Jackson	....	....	....
York	3	....	....
Mt. Vernon	....	....	....
Lakewood	2	1(c)	....
Woonsocket	1	(b)	....
Lexington	2	....	....
Fitchburg	....	0.95(a)	1.96
Stockton—			
North	3/64 x 2	27.1(b)	....
South	....	....	....
Madison	1⅜	2.75(a)	....
Stamford	....	....	....
Austin	¾	1(a)	....
Pontiac	1½-1	3½(a)	0.75
Plainfield	1/16 x 2	13.5(ad)	....

(a)Buried. (b)Dumped. (c)Burned. (d)Spread on land.

TABLE XV.—SLUDGE DATA, IMHOFF TANKS, CITIES 25,000 TO 100,000.

	Liquid Sludge			
City.	Cu. yd. per mil. gal.	Cu. yd. per year.	No. Air Dryings per year.	Moisture per cent on removal from beds.
Schenectady	....	....	8 to 10	....
Canton	13.8	28,126	....	65
York	2.44	707 to 2820	6	65
Lakewood	....	(a)	2	....
Lexington	....	....	....	....
Fitchburg	5.02	4,514	5.73	46
Pontiac	½	....	....	....
Plainfield	3.1	4,000	7.7	75

(a)418 cu. yd. per year dried sludge reported.

TABLE XVI.—SLUDGE DATA, SPECIAL, CITIES 25,000 TO 100,000.

City.	Cu. yd. per mil. gal.	Cu. yd. per year.	No. Air Dryings per yr.	Moisture per cent on removal from bed.
Allentown	30	....	12	75
Brockton	6.3	7415	2	65
Madison, Wis.	27	....	..	..

TABLE XVII.—SLUDGE DISPOSAL, 25,000 TO 100,000.

Dump at Sea	Lagoon.	Air dry and dump.	Run out and plow in.	Into stream at flood.
Schenectady	...	*	...	*
Canton	...	*	...	...
Allentown	...	*	...	...
Brockton	...	*	...	...
Atlantic City	...	...	...	...
Jackson	...	*	...	...
York	...	*	...	...
Fresno	...	...	*	...
Mt. Vernon	...	...	...	...
Lakewood	...	*	...	...
Lexington	...	*	...	...
Fitchburg	...	*	*	...
Stockton—				
South	...	...	...	...
Madison	*	...	*	...
Stamford	...	...	...	...
Austin	...	*	.	...
Pontiac	...	*	...	...
Marion	...	...	...	...
Mansfield	...	...	*	...
Plainfield	...	...	*	...

Department of Agriculture recommends trial crops typical respectively of roots, grain, leaf and fruit.

TABLE XVIII.—SLUDGE USE, CITIES 25,000 TO 100,000.

	Hauled by Farmers.	Used Year After Year.	Money Received.
Schenectady	....	....	....
Canton	Yes	Yes	No
Allentown	Some	....	No
Brockton	Yes	Not on same land	No
Pawtucket	Tried, aband'd.		....
New Britain	No	....	....
York	No	....	....
Fresno	No	....	....
Lakewood	No	....	....
Lexington	Yes, 50%	....	....
Fitchburg	Yes	Yes	....
Stockton	No	....	....
Madison	No	....	....
Austin	No, too much oil	....	....
Pontiac	Yes, 20%	....	$2.00 per c. y.
Mansfield	Yes	....	....
Plainfield	Some	One*	....

*Grows good corn, but use is handicapped by grease. Local board of health prohibits carting or use.

TABLE XIX.—SLUDGE ANALYSES AS REPORTED, CITIES 25,000 TO 100,000.

		Per Cent Dry Basis					
City.	Sp. Gr.	H_2O	Volatile.	Fixed.	Nitrogen.	Ether Sol.	Type of Plant.
Schenectady	1.000	92.7	70	30	2.6	3.5	Imhoff
Canton	0.997	94.3	5	95	2.6	3.5	Imhoff
Allentown	1.05	96	20-30	80 to 70	1 to 0.7	2	Electrolytic
Brockton	1.01	93.8	85.5	14.5	....	...	....
York	....	93	..	..	....	...	....
Mt. Vernon	....	....	..	..	....	...	....
Lakewood	....	....	..	..	....	...	....
Lexington	....	....	..	..	....	...	....
Fitchburg	1.05	87.5	41	59	1.88	7.2	Imhoff
Madison	....	....	..	..	1.21	...	....
Plainfield	....	94	..	..	....	...	....

TABLE XX.—ANALYSES OF SLUDGES RECEIVED FROM SEWAGE TREATMENT WORKS. ALL ANALYSES ON DRY BASIS PER CENT.

Source of Sludge.	Nitrogen.	Grease.	Volatile matter (organic.)	Fixed matter (inorganic)	Nitrogen in volatile matter.
Imhoff Tank—					
Fitchburg, Mass.	1.71	4.6	35.3	64.7	4.84
Columbus, Ohio	2.04	5.5	45.7	54.3	4.46
Batavia, N. Y.	2.93	3.1	47.0	53.0	6.23
Plainfield, N. J.	2.91	4.1	50.7	49.3	5.74
Cleveland, Ohio	2.40	1.6	40.3	59.7	5.95
Atlanta, Ga.	1.37	4.8	34.1	65.9	4.02
Average	2.23	4.0	42.2	57.8	5.28
Secondary Tanks Receiving Effluent of Sprinkling Filters—					
Fitchburg, Mass.	2.25	4.6	43.4	56.6	5.18
Plainfield, N. J.	3.78	2.6	57.6	42.4	6.56
Average	3.02	3.6	50.5	49.5	5.87
Chemical Precipitation—					
Worcester, Mass.	1.62	1.2	41.8	58.2	3.88
Activated Sludge (Sewage)—					
Milwaukee, Wis.	5.82	2.2	67.8	32.2	8.58
Houston, Texas	4.64	7.1	62.9	37.1	7.38
Average	5.23	4.6	65.3	34.7	7.98
(Industrial wastes)—					
Argo, Corn Products	6.03	1.2	75.3	24.7	8.00
Ch'go, tannery wastes	2.18	0.2	49.4	50.6	4.41
Chicago, Stockyards testing station	4.17	6.0	62.6	37.4	6.66

Note.—All these analyses were made in the laboratory of the Sanitary District of Chicago.

Exposition of Power and Mechanical Engineering.—The National Exposition of Power and Mechanical Engineering will open at 1 p. m., Dec. 7, at the Grand Central Palace. It will immediately follow the annual meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers and will remain open until Dec. 13 except on the intervening Sunday. This exposition will be a large scale attempt to display mechanical and power plant apparatus so that the present extraordinary state of development will be apparent not only to the highly trained technical man but to the layman with little knowledge of the severe problems involved in the engineering design and operation of combustion apparatus and power-generating machinery.

Cost of Operation and Maintenance of Sewage Disposal Works at Fitchburg, Mass.

The accompanying table from the annual report of David A. Hartwell, Commissioner of Public Works of Fitchburg, Mass., shows the total cost of operation and maintenance of the different parts of the sewage disposal works of that city for the fiscal year ending Dec. 1, 1921, including administration, laboratory, care of grounds and miscellaneous expenditures not chargeable to any one account, but divided pro rata among all the accounts:

Account.	Total cost of operation and maintenance.	Cost per million gallons treated.	Cost per capita served.
Grit chambers	$ 1,157.29	$ 1.29	$0.029
Siphon chamber	437.78	.49	.011
Imhoff tanks	5,716.22	6.36	.148
Sludge beds	1,636.19	1.82	.042
Trickling filter	2,527.44	2.81	.064
Secondary tanks	1,532.51	1.70	.040
Total	$13,007.43	$14.47	$0.334

Rivers and Harbors Congress.—The 18th Convention of the National Rivers and Harbors Congress will be held Dec. 6 and 7 at Washington, D. C.

Concrete Groined Arches for Reservoir Roofs

Comparison of Existing Structures and Suggested Rules That Should Be of Use in Design Given in Paper in October Proceedings of the American Society of Civil Engineers

By PHILIP O. MACQUEEN,
Bay City, Mich.

The usual methods attempted in the design of concrete groined arches are based on the principles that are used in the design of simple cylindrical arches. These methods, as applied to concrete groined arches, have been fully developed by Thomas H. Wiggin,[*] M. Am. Soc. C. E., and also by Leonard Metcalf[†], M. Am. Soc. C. E. It is unnecessary, therefore, to repeat the complete mathematical analysis. The method, although simple, is somewhat cumbersome, and is not completely presented in textbooks. The article by Mr. Wiggin contains several methods of designing groined arches, but for the purpose of this paper, it will be sufficient to summarize briefly the generally preferred method.

Preferred Method of Design.—In general, there are two steps in this preferred method of design: First, the selection of a groined arch of certain dimensions; and, second, the investigation of this arch for stability under the required loadings by the "hypothesis of least crown thrust." This hypothesis assumes that the true "line of resistance" is that for which the thrust at the crown of the arch is the least possible consistent with equilibrium. The strength and stability of the arch depend on the position of the "line of resistance" and the position of this line, in turn, depends on the amount, direction and point of application of the crown thrust. The crown thrust is assumed to act horizontally at the upper third point of the thickness of the arch at the crown. The external loading in this case is considered as acting on a triangular area obtained by assuming that the arch is cut vertically along the groined lines, as this method of loading will be found to give greater unit stresses at the "joint of rupture" than other methods. As a condition of equilibrium, it is further assumed that the center of pressure will always remain within the middle-third of every joint. With these assumptions and correct data in regard to the dead and the live loads, the crown thrust and the thrust at the joint of rupture are easily (although somewhat laboriously) computed by means of the usual methods as given in textbooks on simple cylindrical voussoir arches. The final step in the design consists in laying out a cross-section of the arch on a large scale, and making a careful graphical check of the problem and the position of the "lines of resistance" for the various loadings.

The preferred method of design previously outlined, although cumbersome, has always produced safe structures and, therefore, it is used. With good concrete the factor of safety is high, as has been proved many times. Arches designed for the normal loading of 2 ft. of earth plus a live load of 100 lb. per sq. ft. have safely carried a load of 10 ft. of earth. Cases are also on record of other arches carrying heavy concentrated loads far in excess of those anticipated. As an example of a still more severe test, arches unsupported at the crown have been loaded to at least four times the allowable load, thus proving the strength of the structure. Groined arch roofs have failed, but, in each case, the failure has been due to faulty foundations, poor concrete, or to unusual stresses at certain times during construction. No cases are on record of groined arches that have failed on account of poor design or even excess loading.

Notwithstanding this proved strength, however, the method of designing groined arches is empirical, and a strict mathematical or even logical method of their design is impossible. This statically indeterminate condition is due principally to the multiplicity of the points of support so that, although the loading on the groined arch roofs is symmetrical and easy to compute, it is, nevertheless, practically impossible to develop a formula that will give a logical distribution of the stresses caused by the loading. The flat slab type of concrete structure is statically indeterminate for the same reason. The preferred method of design for groined arch roofs is that which gives the greatest unit stresses and, therefore, the highest factor of safety. The labor involved in this method can be appreciated by the fact that the average engineer unless experienced in this work, usually will require a month to lay out, investigate, check, compare and finally select a groined arch for an important structure. Simple, rational formulas have replaced the lengthy methods originally used in the design of flat slab roofs so that it is consistent with economical engineering practice, that if possible, the complicated method of design of groined arches should be replaced with much simpler methods.

Comparison of Typical Groined Arches.—Strength and economy are the two most important items in the design of groined arches. Table I presents a comparison of 30 typical groined arches. The dimensions and general data for most of these arches have been taken from a table compiled by John H. Gregory, M. Am. Soc. C. E., and published in an article[‡] by J. W. Armstrong, M. Am. Soc. C. E. The arches are listed according to the length of span. The ratios given in Columns 9 and 10 and the average thicknesses of the groined arch roofs given in Column 11, have been calculated by the writer.

Table II gives a summary of the various unit stresses and crown thrusts obtained in a few typical arches. In each case, the stresses were calculated by the method of "least crown thrust," as outlined previously.

Tables I and II present a number of interesting comparisons which will be discussed in the order of their importance.

Form of Groined Arch Roofs.—The form of groined arch reservoir roof invariably selected by designing engineers consists of one in which the intrados is formed by semi-elliptical cylindrical surfaces and the extrados by parabolic cylindrical surfaces. The arches listed in Tables I and II are of this type. The elliptical shape of the intrados lends itself to a systematic arrangement at the column supports and the flattened form of the arch allows for long spans with a minimum loss of head-room. The parabolic extrados, in its turn, gives a uniformly increasing thickness to the arch. Taken together, the two curves are excellently adapted for groined arch reservoir roofs, and it is difficult to conceive that more effective curves could be used.

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[*] Engineering Record, March 12, 1910, p. 298.

[†] Transactions, Am. Soc. C. E., Vol. XLIII, (1900), p. 37.

[‡] Engineering Record, Nov. 15, 1913.

TABLE I.—DATA FOR CONCRETE GROINED ARCHES FOR RESERVOIR ROOFS.

No.	Date	Location.	Clear span (2 a), in feet.	Rise of intrados (b), in feet.	Crown thickness (t), in feet.	Rise of extrados (h), in feet.	Span, center to center, of columns (2 c), in feet.	Ratios: $\left(\frac{b}{2a}\right)$	Ratios: $\left(\frac{h}{b+t}\right)$	Average thickness of roof, in feet.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	1908	Watertown, N. Y.	10.000	1.500	0.500	0.833	11.500	0.150	0.417	0.562
2	1909	Providence, R. I.	10.250	2.500	0.500	1.250	11.917	0.244	0.417	0.635
3	1903	Ithaca, N. Y.	10.500	1.500	0.500	0.833	12.000	0.143	0.417	0.568
4	1909	Springfield, Mass.	11.333	2.000	0.500	1.250	13.000	0.177	0.500	0.566
5	1911	Toronto, Ont., Canada	11.333	2.000	0.500	1.167	13.000	0.177	0.467	0.582
6	1910	Owen Sound, Ont., Canada	11.500	2.500	0.500	1.167	13.000	0.218	0.388	0.625
7	1902	Washington, D. C.	11.833	2.500	1.500	1.417	13.667	0.211	0.472	0.606
8	1899	Albany, N. Y.	11.917	2.500	0.500	0.500	13.667	0.210	0.167	0.774
9	1900	Superior, Wis.	12.000	2.500	0.500	0.500	13.667	0.208	0.167	0.747
10	1903	Washington, D. C.	12.167	2.500	0.500	1.417	14.000	0.206	0.472	0.600
11	1912	Roland Park, Md.	13.000	2.667	0.500	1.500	14.667	0.205	0.473	0.593
12	1907	Philadelphia, Pa.	13.167	3.000	0.500	1.750	15.000	0.228	0.500	0.609
13	1907	Lawrence, Mass.	13.167	2.750	0.500	1.667	15.000	0.209	0.513	0.590
14	1908	Pittsburgh, Pa.	13.167	3.000	0.500	1.750	15.000	0.228	0.500	0.609
15	1904	Philadelphia, Pa.	13.417	3.000	0.500	1.750	15.250	0.224	0.500	0.607
16	1913	Baltimore, Md.	13.500	3.000	0.500	1.750	15.000	0.222	0.500	0.582
17	1912	Grand Rapids, Mich.	13.833	3.000	0.500	1.833	15.000	0.217	0.524	0.543
18	1907	Philadelphia, Pa.	14.000	3.000	0.500	1.750	15.833	0.214	0.500	0.604
19	1902	Milford, Mass.	14.000	3.000	0.500	1.500	16.000	0.214	0.428	0.658
20	1909	Springfield, Mass.	14.000	2.750	0.500	1.500	16.000	0.196	0.462	0.623
21	1916	Cleveland, Ohio.	14.080	3.500	0.500	2.000	15.750	0.249	0.500	0.618
22	1908	Columbus, Ohio.	15.167	3.167	0.500	1.917	16.833	0.209	0.522	0.668
23	1905	Washington, D. C.	15.500	3.500	0.500	2.083	18.000	0.226	0.522	0.646
24	1908	Pittsburgh, Pa.	15.750	4.000	0.500	2.167	18.000	0.254	0.482	0.683
25	1912	New York City	16.000	3.750	0.500	2.000	18.000	0.234	0.470	0.653
26	1913	Minneapolis, Minn.	16.333	3.500	0.500	2.000	18.000	0.214	0.500	0.600
27	1913	Montreal, Que., Canada	17.000	4.250	0.500	2.000	19.000	0.250	0.422	0.700
28	1912	New York City*	18.000	4.500	0.500	2.500	20.000	0.250	0.500	0.646
29	1912	New York City*	19.160	5.000	0.500	2.583	22.000	0.261	0.469	0.744
30	1920	Cleveland, Ohio*	17.960	4.500	0.500	2.500	20.292	0.253	0.500	0.675

* Under construction or proposed.

TABLE II.—UNIT STRESSES AND CROWN THRUSTS CALCULATED BY METHOD OF "LEAST CROWN THRUST" FOR THREE TYPICAL GROINED ARCHES.

No	Clear span (2 *a*), in feet	Rise of intrados (*b*), in feet.	Crown thickness (*t*) in feet.	Rise of extrados (*h*), in feet	Span, center to center, of columns (2 *c*), in feet	Arch Stresses for Loading of 2 Ft of Earth, Plus Live Load of 100 Lb. per Sq Ft. Crown thrust, in pounds.	Maximum unit compression at crown in pounds per square inch.	Maximum unit compression at joint of rupture, in pounds per square inch.	Maximum unit shear, in pounds per square inch
1	17.96	3.75	0.50	2.25	20.292	5 310	148	267	59
2	17.96	4.00	0.50	2.25	20.292	5 120	142	238	55
3	17.96	4.50	0.50	2.50	20.292	4 640	129	210	51

Length of Span.—The length of span is more a question of economy than of strength, although strength is an important item for investigation. If the columns are long, the span should also be long, in order to save concrete by a reduction in the number of columns. The calculations must also include the average thicknesses of the roofs, and several comparisons should be made. Confidence in the strength of groined arch roofs has increased rapidly in the past twenty years and the tendency is to use longer spans than was customary in the early days. Spans as short as 10 ft. would hardly be considered at the present time unless the groined arch roof was intended to support very heavy loads, such as filter tanks. For columns less than 20 ft. in length, the average span used at present is about 15 ft., center to center of columns; whereas for columns 20 to 30 ft. in length, the span is usually 18 to 20 ft. A span of 20 ft. is probably the maximum which could be recommended for groined arch roofs.

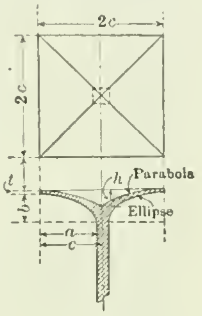

Fig. 1.

Crown Thickness.—As shown in Table I, the crown thickness in every case has been taken as 6 in., and the comparison, therefore, is simple. It might be argued that the crown thickness for the arches with the shorter spans could be less than that given, but this is not the case. With the loads in question (normally 2 ft. of earth plus a live load of 100 lb. per square foot, the 6-in. thickness is about the minimum that could be recommended. Engineers feel responsible for the safety of the structures they design and hesitate to use excessively thin sections, although calculations may indicate that such sections are thicker than necessary. It will readily be seen, however, from Table II that a thickness greater than 6 in. is uncalled for, as all the compressive unit stresses at the crown are less than 150 lb. per square inch. A reasonable increase in the loading, or in the length of the span, would possibly give a maximum compressive unit stress at the crown of 300 lb. per square inch, but even this would be safe. The use of 6 in. for the crown thickness for all concrete groined arch reservoir roofs, therefore does not seem to be unreasonable.

Average Thickness of Roof.—In order to make a study of the economy of the several groined arches selected for comparison, it is necessary to calculate the volume of concrete contained in each. This study is easily made by formulas derived by Mr. John H. Gregory and W. B. Fuller, M. Am. Soc. C. E. The volume (V) of a single square groined arch roof section (Fig. 1), above the springing line of the intrados is calculated as follows:

$$V = m + n - p$$

$$m = 4b\left[c^2 + \frac{2}{3}a^2 - \frac{n}{2}a\ c\right],$$

$$n = 4c^2 t$$

$$p = \frac{2}{3}c^2 h$$

which there is no coal, 500 square in which,

a = one-half the clear span;
b = rise of intrados;
c = one-half of the span, center to center, of columns;
h = rise of extrados; and
t = crown thickness.

When the clear span, crown thickness and span, center to center, of columns, have been selected, the quantities, $4\left[c^2 + \frac{2}{3}a^2 - \frac{n}{2}a\ c\right]$ and $4c^2t$, become constants which may be expressed by k and k′. The formula for volume then becomes:

$$V = b\ (k) + k' \frac{2}{3}c^2\ h$$

The average thickness of the groined arch roof, which is a convenient method of expressing the volume, is then obtained by dividing the volume by ($4c^2$) the total projected area of the groined arch section. All dimensions should be given in feet. Tables III and IV have been calculated in order to show the effect of the change of the rise of the intrados and extrados on the volume of concrete. In Table III, the rise of the intrados has been made the variable and in Table IV, the rise of the extrados has been made the variable. The curves (Figs. 2 and 3) have been plotted from the results given in Tables III and IV. It will be observed that the average thicknesses of the groined arch roofs increase directly with the increase in the rise of the intrados and inversely with the rise of the extrados. For the purpose of comparison, tables and curves similar to those just mentioned should be prepared for each new span selected for investigation. It will also be found that the average thickness decreases directly with the span. The volumes of concrete contained in the columns must be included in the final comparison.

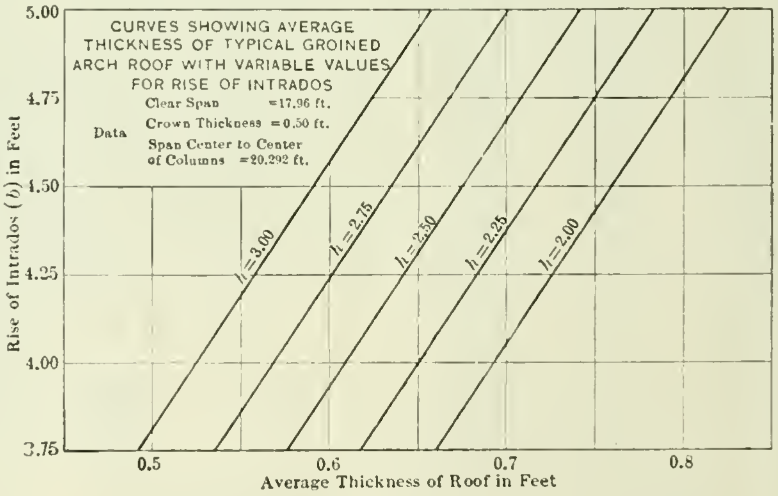

Fig. 2.

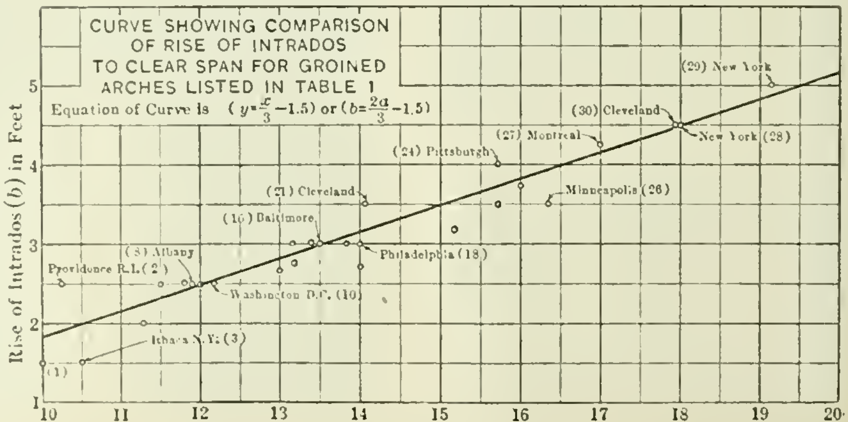

Fig. 3.

TABLE III.—CALCULATED AVERAGE THICKNESS OF A TYPICAL GROINED ARCH ROOF WITH VARIABLE VALUES FOR THE RISE OF INTRADOS.

No	Clear span (2 *a*), in feet.	Rise of intrados (*b*), in feet.	Rise of extrados (*h*), in feet.	Crown thickness (*t*), in feet.	Span, center to center, of columns. (2 *c*), in feet.	RATIOS. $\left(\frac{b}{2a}\right)$	RATIOS. $\left(\frac{h}{b+t}\right)$	Average thickness of roof, in feet.
				0.50				
1	17.96	3.75	2.00	0.50	20.292	0.209	0.471	0.661
2	17.96	4.00	2.00	0.50	20.292	0.223	0.445	0.693
3	17.96	4.25	2.00	0.50	20.292	0.237	0.422	0.726
4	17.96	4.50	2.00	0.50	20.292	0.252	0.400	0.758
5	17.96	4.75	2.00	0.50	20.292	0.265	0.381	0.792
6	17.96	5.00	2.00	0.50	20.292	0.278	0.364	0.825
7	17.96	3.75	2.25	0.50	20.292	0.209	0.530	0.618
8	17.96	4.00	2.25	0.50	20.292	0.223	0.500	0.652
9	17.96	4.25	2.25	0.50	20.292	0.237	0.474	0.681
10	17.96	4.50	2.25	0.50	20.292	0.252	0.450	0.718
11	17.96	4.75	2.25	0.50	20.292	0.265	0.428	0.750
12	17.96	5.00	2.25	0.50	20.292	0.278	0.409	0.782
13	17.96	3.75	2.50	0.50	20.292	0.209	0.588	0.577
11	17.96	4.00	2.50	0.50	20.292	0.223	0.556	0.610
15	17.96	4.25	2.50	0.50	20.292	0.237	0.526	0.642
16	17.96	4.50	2.50	0.50	20.292	0.252	0.500	0.675
17	17.96	4.75	2.50	0.50	20.292	0.265	0.476	0.708
18	17.96	5.00	2.50	0.50	20.292	0.278	0.454	0.742
19	17.96	3.75	2.75	0.50	20.292	0.209	0.647	0.536
20	17.96	4.00	2.75	0.50	20.292	0.223	0.612	0.567
21	17.96	4.25	2.75	0.50	20.292	0.237	0.580	0.602
22	17.96	4.50	2.75	0.50	20.292	0.252	0.550	0.634
23	17.96	4.75	2.75	0.50	20.292	0.265	0.524	0.666
24	17.96	5.00	2.75	0.50	20.292	0.278	0.500	0.700
25	17.96	3.75	3.00	0.50	20.292	0.209	0.706	0.494
26	17.96	4.00	3.00	0.50	20.292	0.223	0.667	0.526
27	17.96	4.25	3.00	0.50	20.292	0.227	0.632	0.558
28	17.96	4.50	3.00	0.50	20.292	0.252	0.600	0.593
29	17.96	4.75	3.00	0.50	20.292	0.265	0.572	0.625
30	17.96	5.00	3.00	0.50	20.292	0.278	0.545	0.657

Rise of Intrados.—The rise of the intrados is usually considered one of the more difficult questions to solve in the design of groined arch roofs, as this factor involves a question of both strength and economy. Fig. 4, plotted from data given in Table I, shows the comparison of the rise of the intrados to the clear span. The rise of the intrados is observed to increase gradually with the increase of the clear span, and the average rate of this increase is shown by the curve in Fig. 4, the equation of which is:

$$y = \frac{x}{3} - 1.5$$

or,

$$b = \frac{2a}{3} - 1.5.$$

The rise of the intrados to be used in the average groined arch roof, therefore, may be expressed as being approximately equal to one-third of the clear span minus the constant (1.5). The effect of the rise of the intrados on the strength of the groined arch is shown in Table II, in which it may be noted that the unit stresses and the unit shares decrease steadily with the rise of the intrados. Referring to Tables III and IV and Figs. 2 and 3, however, it is observed that the average thickness of the groined arch roof increases directly with the increase of the rise of the intrados. These two conditions, therefore, are opposed to each other, and it is necessary to make a careful study of both in order to arrive at a logical selection of the most suitable dimensions.

The ratio of the rise of the intrados to the clear span is given in Column 9 of Table I. As this ratio varies between the approximate limits of 0.20 and 0.25, the rise of the intrados, therefore, may also be expressed as approximately equal to one-fifth of the clear span for the shorter spans and one-fourth of the clear span for the longer spans.

Rise of Extrados.—The rise of the extrados used in the average groined arch is given in Table I, in which also (Column 10) is given the ratio $\left(\frac{h}{b+t}\right)$ of the rise of the extrados to the sum of the rise of the intrados and the crown thickness. In general, this ratio is observed to have an approximate value of 0.50, and the average rise of the extrados to be used, therefore, may be expressed as being equal to one-half of the total rise of the arch, that is, the sum of the intrados and the crown thickness. It will be observed further that the unit stresses increase directly with the rise of the extrados and that the average thickness of the arch increases inversely with the rise of the extrados. These two conditions, therefore, are also opposed to each other, and it is necessary to make a careful study of both in order to make a logical selection of the most suitable dimensions.

Unit Stresses and Loadings.—As shown in Table II, the compressive unit stresses obtained in the calculations for groined arch roofs are much lower than those normally used in the design of other concrete structures. As a result of this condition, the specifications generally call for concrete containing a relatively small quantity of cement, the proportions of the mix usually selected being either 1:2.5:7 or 1:3:5. The saving in cost of the cement alone over a 1:2:4 mix, therefore, is from 5 to 10 per cent. In a structure containing 10,000 cu. yds. and with concrete at $15 per cu. yd., this saving would be about 2 per cent of the total cost. In this connection, it is well to call attention to certain other phases of this question. In the first place, the unit stresses obtained are hardly more than guesses and it is not altogether wise to place too much confidence in the calculations. In the second place, the calculated unit shears are relatively high and there is, perhaps, danger in this condition in case extremely lean concrete mixtures are used. In general, it is believed to be unwise to use concrete mixtures leaner than 1:2.5:5, and, in many cases, a 1:2:4 concrete is perhaps preferable.

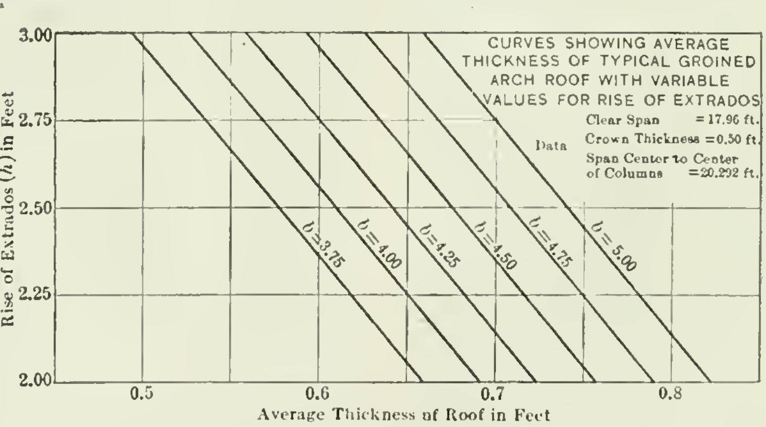

Fig. 4.

Rules for Design.—Summing up the various comparisons, it will be convenient to express the final results in the form of a few simple rules, as follows:

(a).—The form of groined arch roof in which the intrados consists of a semi-elliptical cylindrical surface and the extrados of a parabolic cylindrical surface is excellently adapted to this type of construction and, therefore, it should be used.

(b).—Spans from 15 to 20 ft., center to center, of columns may be used with safety. Economy will always call for long columns with long spans. In selecting the most suitable length of span, the calculations should always include the volume of concrete in the roof.

(c).—A crown thickness of 6 in. may be used satisfactorily for practically all groined arch reservoir roofs.

(d).—The average thickness or volume of the groined arch reservoir roof should be calculated carefully for all trial arches selected, as this factor is an important guide in the determination of the most suitable arch to be used.

(e).—In general, the rise of the intrados (taken only to the nearest 0.25 ft.) should be about equal to one-third of the clear span minus 1.5, that is, $b = \frac{2a}{3} - 1.5$.

(f).—In general, the rise of the extrados (taken only to the nearest 0.25 ft.) should be about equal to one-half of the sum of the rise of the intrados and the clear span, that is, $h = \frac{b+t}{2}$.

(g).—The unit stresses obtained in the calculations should be used with caution, and it should be realized that these stresses are somewhat problematical. In general, the proportions of

TABLE IV.—CALCULATED AVERAGE THICKNESS OF A TYPICAL GROINED ARCH ROOF WITH VARIABLE VALUES FOR THE RISE OF EXTRADOS.

No.	Clear span (2a), in feet.	Rise of intrados (b) in feet.	Rise of extrados (h), in feet.	Crown thickness (t), in feet.	Span, center to center, of columns (2c), in feet.	Ratios		Average thickness of roof, in feet.
						$\left(\frac{b}{2a}\right)$	$\left(\frac{h}{b+t}\right)$	
1	17.96	3.75	2.60	0.50	20.292	0.209	0.471	0.661
2	17.96	3.75	2.25	0.50	20.292	0.209	0.530	0.618
3	17.96	3.75	2.50	0.50	20.292	0.209	0.588	0.577
4	17.96	3.75	2.75	0.60	20.292	0.209	0.647	0.535
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7	17.96	4.00	2.25	0.50	20.292	0.223	0.500	0.652
8	17.96	4.00	2.50	0.50	20.292	0.223	0.556	0.610
9	17.93	4.00	2.75	0.50	20.292	0.223	0.612	0.567
10	17.96	4.00	3.00	0.50	20.292	0.223	0.667	0.526
11	17.96	4.25	2.00	0.50	20.292	0.237	0.422	0.726
12	17.96	4.25	2.25	0.50	20.292	0.237	0.474	0.684
13	17.06	4.25	2.50	0.50	20.293	0.237	0.526	0.642
14	17.96	4.25	2.75	0.50	20.292	0.237	0.580	0.602
15	17.96	4.25	3.00	0.50	20.292	0.237	0.632	0.558
16	17.96	4.50	2.00	0.50	20.292	0.252	0.400	0.758
17	17.96	4.50	2.25	0.60	20.292	0.252	0.450	0.718
18	17.96	4.50	2.50	0.50	20.292	0.252	0.500	0.675
19	17.96	4.50	2.75	0.50	20.292	0.252	0.550	0.634
20	17.96	4.50	3.00	0.50	20.293	0.252	0.600	0.593
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30	17.96	5.00	3.00	0.50	20.292	0.278	0.545	0.657

concrete used in groined arch roofs should be not leaner than a 1:2.5:5 mix, and, in many cases, a 1:2:4 mix is preferable. The normal loading for the roof is usually taken as 2 ft. of earth plus a live load of 100 lb. per sq. ft.

The question of whether to use a groined arch of a flat slab roof for a reservoir is one which frequently involves differences of opinion. Both types are acceptable, although, in certain cases, one type is preferable to the other. For small, shallow reservoirs of an area of, say, less than 1 acre, the flat slab roof may be more economical on account of the lower cost of form work, and, perhaps, better standardized methods of construction. For larger and deeper reservoirs, however, covering an area of several acres, the groined arch roof will prove much more economical than the flat slab roof.

Filing System for Water Resources Data

Dominion Water Power Branch System Provides Not Only an Index to But Also An Inventory

An index inventory filing system for recording, collating and analyzing water resources data, the general principles of which will be found suitable to all organizations administering or interested in water resources, was placed in service some months ago by the Dominion Water Power Branch of the Canadian Department of the Interior. The system is described by J. T. Johnston, Assistant Director of Water Power, in a Water Resources Paper, from which the notes following are taken.

Basin of Index Inventory System.—The increasing and continuous accumulation of water resources data in the Dominion Water Power Branch compelled the evolution of a convenient and logical system for recording and filing the material.

It was realized that the characteristics of the data which are essential to the proper consideration and analysis of water resources are so varied that a purely topic and alphabetical index would be cumbersome and unsatisfactory. A water resources filing system to be satisfactory must necessarily be graphical as well as analytical since a large proportion of the data can be most readily referenced on properly designed plans and maps. Such information as the location of waterpower sites, waterpower developments, storage reservoirs, stream measurement, stations, meteorological stations, etc., should be graphically recorded so that an entire district is visualized enabling one to secure a comprehensive grasp of any particular water or general power situation. In conjunction with this graphical representation a topic or alphabetical index is essential for recording such actual detailed data as records of run-off, meteorogical conditions, existing plans, reservoirs, possible sites, etc., etc., which can only be properly recorded on cards and in folders in the customary manner.

In brief, the system involves the division of the Dominion into suitably-sized areas based on the drainage basins, and the filing of the water resources data for these various areas under suitable topic headings. A general key map shows the index number of any particular area in question, and the available data in that region is automatically brought to hand by referring to the corresponding topic reference cards. A cross index of river, lake or place names with the index divisions provides a ready means of reference when the operator is not acquainted with the location of the district or territory for which data is required.

The fact that water resources information in general is based upon, and may be advantageously tied into, water-shed areas, suggested the adoption of a graphical index based upon the drainage areas rather than upon arbitrary divisions by longitude and latitude. The system of division and subdivision which has been adopted has been developed with the idea of securing index maps of a scale suitable to record any desired data.

General Scheme of Subdivisions.—The Dominion has been divided into 11 numerical major divisions as follows:

1. Maritime Provinces drainage.
2. St. Lawrence River drainage.
3. Northern Quebec drainage.
4. Southwest Hudson Bay drainage.
5. Nelson River drainage.
6. Western Hudson Bay drainage.
7. Great Slave Lake drainage.
8. Pacific drainage.
9. Yukon River drainage.
10. Arctic drainage.
11. Mississippi River drainage.

The great natural watersheds and drainage slopes form the basis of these major divisions. These major areas are each redivided alphabetically and labeled for reference purposes, 1A, 1B, 1C, etc., etc.; 2A, 2B, 2C, etc., etc.; 3A, 3B, 3C, etc., etc. For sections of the country where more detailed data are to be recorded, these subdivisions are again subdivided alphabetically and named for reference purposes 1AA, 1AB, 1AC, etc., etc.; 2AA, 2AB, 2AC, etc., etc.; 3AA, 3AB, 3 AC, etc., etc.

Following the division and subdivision of the Dominion into suitably-sized areas, these areas were photographically reproduced in a series of index maps, 12 in. by 9½ in. within the border, suitable for the plotting of the graphic records. These reproductions were made from the latest published federal and provincial maps. The procedure adopted was to first photograph the complete watersheds of the major rivers and afterwards the index divisions, the lattter to such a scale as to reproduce in readily readable form the information on the original map. These index maps have been printed on 14-in. by 11-in. sheets and bound in loose leaf covers, the whole series forming a complete reproduction of the latest published maps of the Dominion.

The series of index figures and letters forms a basis which for reference purposes, is applicable to all water resources data. The series numbers are flexible and capable of any degree of expansion. Undeveloped power sites in section 5AB are referred to as Undeveloped Sites 5AB$_1$, 5AB$_2$, 5AB$_3$, etc. Stream measurement stations are similarly referred to as Stream Measurement Stations 5AB$_1$, 5AB$_2$, 5AB$_3$. In the same way developed power sites, meteorological stations, developed and undeveloped storage reservoirs, etc., etc., are given reference numbers and are graphically plotted for permanent record on the index maps.

The system of index maps is likewise flexible and permits of any degree of expansion which may be desirable or necessary. Any portion of any subdivision may, if desired, be enlarged to record graphically the details of any particular situation or project.

The index maps at all times record the locations and index numbers of all the water resources items which can be graphically recorded, the first step in filing being to plot these items on the maps in accordance with an established legend. The maps are used only for recording the symbols and index numbers. They are not designed to record actual detailed data. The index numbers allocated are also kept up to date in a loose leaf index number record book, a sample page of which is attached.

Complimentary System of Cards and Folders.—Complimentary to the graphical index, a system of cards and folders has been developed for the purpose of referencing and filing the great amount of data which is now available in published and in special reports and in the form of records of all descriptions covering rivers, run-off, meteorological conditions, existing power plants, possible power sites, reservoirs, water snpply, drainage, reclamation, etc, etc. The general principle adopted is to file under topic headings the data in each subdivision. Where the information to be filed is of a general character, it is also referenced under the larger diviisons. The following series of cards have been developed to date:

WHITE.
Form R-80—Developed water-power.
Form R-81—Undeveloped water-power.
Form R-82—Coal, gas and oil plants.
Form R-83—Electric railways.
PINK.
Form R-84—Run-off data.
Form R-85—Meteorological data.
Form R-86—Gauge records.
Form R-87—Altitudes and bench-marks
BUFF.
Form R-88—Water supply.
Form R-89—Sewage disposal.
Form R-90—Drainage and reclamation.
Form R-91—Irrigation.
SALMON.
Form R-92—Developed reservoirs.
Form R-93—Undeveloped reservoirs.
Form R-94—Power market.
Form R-95—General data.
BLUE.
....
....
....
....

The number of topic headings adopted rendered the use of a separate color for each card inadvisible, and they have accordingly been grouped in fours as above. Blanks are available for such further headings as may become necessary. The number of topic headings can be extended indefinitely.

These cards are purely reference cards and each records for its particular division or subdivision, the references to the data which are available in that area and under that heading. The division group of cards forms an inventory of the entire pertinent data available for the area.

For example in division 5PF, the "Developed Water Power" card records as follows:

Site $5PF_1$—City of Winnipeg Municipal Power Plant.
Full description—See W. R. Paper No. 3, p. 148.
Brief description—See W. R Paper No. 16, p. 195.
Summary statement—See W. R. Paper No. 27, p. 56.
Also see Folder 5PF.
Etc., etc.
Site $5PF_2$—Winnipeg Electric Railway Co.'s Plant.
Full description—See W. R. Paper No. 3, p. 138.
Brief description—See .V. R. Paper No. 7, p. 47.
Summary statement—See W. R. Paper No. 27, p. 57.
Also see Folder 5PF.
Etc., etc.

The "Undeveloped Power" card records as follows:

Site $5PF_1$—Pine Falls power site—Full analysis—See W. R. Paper No. 3, p. 186, Brief Description—See W. R. Paper No 16, p. 201.
Etc:, etc.
Sites $5PF_2$, $5PF_3$, $5PF_4$, are similarly referenced.

The "Run-off," "Meteorological," "Gage Record" and "Reservoir" cards each records its references in a similar manner. The entire series of cards for each subdivision is filed behind the index guide for that subdivision. The references cover the complete pertinent water resources data available for the division area.

The cards are intended to record references only. If desirable, however, they may be used for recording actual data.

With each subdivision and its series of cards there is provided a folder similarly labeled for the filing of all loose computations, newspaper clippings, run-off measurements and other pertinent data. This folder may be subdivided with sub-folders for the topic headings if desirable.

Cross Reference of River and Place Names.—To supplement the subdivision index an alphabetical index of rivers and streams is nnder preparation showing the relation of the same to the main river systems and to the area, division or subdivision in which they are located. A similar index of place names is contemplated. This supplemental index will provide a key to the index proper, cross-referencing data for areas whose location is uncertain to the enquirer.

A section of the cross index of river and stream names, as prepared for the province of New Brunswick follows:

River cr Stream—Tributary to	Index Div.
A	
Ahoushagan—Northumberland strait	1BT
Aldouane—Gulf of St. Lawrence....	1BR
B	
Bass—Chaleur	1BL
Barnaby—Miramichi, Main southwest	1BO
Barnaby, Right Hand Branch—Barnaby	1BD

Summarized Digest to Accompany Each Site.—For the purpose of ready reference, a summarized digest is prepared along standard lines covering the more important features and details of each power or reservoir site. The digests are typed on onion skin paper for the sake of compactness.

The ordinary headings nnder which information is recorded as follows:

Developed Power—Company or Owner, River, Rapid or Fall, Location, Accessibility, Head, Water Supply, Storage, Turbine Installation, Generator Installation, New Installation Contemplated, Total Energy Generated, Use of Power, Municipalities Served, Power Available for Sale, Reserve Plant, Fuel, Capital, Remarks, Sources of Data.

Undeveloped Power—River, Rapid or Fall, Location, Accessibility, Head, Water Supply, Storage, Possible Power, Estimates, Market, Remarks, Sources of Data.

Developed Reservoir—Reservoir, River, Data of Construction, By Whom Constructed, Purpose of Construction, By Whom Controlled, Accessibility, Area of Surface, Area of Drainage Basin, When Storage Required, Capacity (B. C. F. & Ac. Ft.), Water Supply, Influence on Outflow, Interests Benefiting, Costs (Total and Unit), Control Dam (Discharge Capacity, Character of Control, Description), Remarks, Sources of Data.

Undeveloped Reservoir—Reservoir, River, Accessibility, Area of Surface, Area of Drainage Basin, When Storage Required, Capacity (B. C. F. & Ac. Ft.), Water Supply, Influence on Outflow, Dam Required (Length, Height, Foundation, Character), Estimates, Interests to Be Benefited, Remarks, Sources of Data.

Each uigest comprises in concise form the pertinent data available in respect to the site under consideration. Where necessary the accuracy and dependability of the data is commented upon.

Power River Synopsis.—Complementary to the power and reservoir site digests there are prepared synoptic statements covering each of the more important power rivers, treating the river system in each case as a nnit and including in brief form available data covering:

General description of river and basin, water supply, run-off records, storage—developed and undeveloped reservoirs, ice conditions, power available—developed and nndeveloped—estimates, market, remarks, sources of data.

To Inaugurate the Index-Inventory System.—The first step in the application of the index-inventory filing system to the recording of water resources data is the determination of the index divisions, and the preparation of the index maps, cards and folders. Before proceeding with the referencing it will be found an advantage to allocate index numbers to sites and structures which it is desired to record, and for which information is to hand, such as developed and undeveloped power sites, stream measurement stations, etc.

The next step comprises a careful research into all existing records of water resources data, such as government reports published or filed, technical periodicals, press articles, special reports, files and plans, etc., etc. As this research proceeds the necessary references are placed on the index maps and cards, and the referenced data is filed in corresponding folders or placed in an indexed reference library. The effect of this is to bring all the existing water resources data to the surface and make it available for present and future reference and use. Material coming to hand subsequently is readily referenced and filed.

In so far as the filing system is concerned, all that is necessary to know, in order to secure the complete water resources information on hand in respect to any district, is a knowledge of the location of the district. The key plan thereupon gives the index number, and the corresponding cards and index maps supply at once complete, references to all the information that is available. Where the location of the district is unknown or uncertain the cross index of river and place names is utilized.

Advantage of the Filing System.—Some of the outstanding advantages of this filing system may be listed:

1. The system is essentially simple in conception and the actual filing of data easily accomplished.

2. Its simplicity renders the filed material and references almost automatically available to any one interested in any particular district, or, in other words, the medium of a skilled filing clerk is not necessary for the securing of data when required.

3. Being founded on drainage areas, it compiles the data in the form best adapted for the consideration of hydraulic problems.

4. It visualizes the data on the index maps enabling the user to form an intelligent conception of the entire, as well as local water-shed conditions.

5. Once properly inaugurated it forms a complete compendium of water resources references and material.

6. It is flexible and capable of enlargement or contraction to the requirements of any organization using it.

7. It permits the continuous addition of new filing references.

8. It is equally adapted to the requirements of Federal and Provincial organizations.

9. When adopted generally by Federal and Provincial administrative or investigatory departments and by other organizations interested in the study of water resources, it renders the known pertinent data conveniently available for mutual interchange and use.

10. Its adoption by Federal and Provincial organizations results in uniformity in methods of filing, collating and analyzing water resources data throughout the Dominion.

Cost of Sewer Construction at Providence, R. I.

The following table reprinted from the annual report of M. H. Bronsdon, City Engineer, Providence, R. I., gives the average depth of cut, nature of excavation, and contract cost of labor per foot, on the different sizes of regular sewers built during 1921:

Items.	Average nature of excavation	Average depth of cut. Ft.	Avg. cost per Foot.
*6 in. pipe	Sand, dry	10.50	$1.00
*6 in. pipe	Sand and gravel	10.50	1.69
*6 in. pipe	Hard pan	10.50	2.05
*6 in. pipe	Filling	10.50	1.32
†8 in. pipe	Sand	8.00	.94
†8 in. pipe	Sand and gravel	8.00	1.39
†8 in. pipe	Filling	8.00	1.08
†8 in. pipe	Hard pan	8.00	1.72
†8 in. pipe	Rock	8.00	2.00
8 in. pipe sewer.	Sand	10.00	2.00
12 in. pipe sewer.	Sand, wet	14.00	5.00
12 in. pipe sewer.	Sand, dry	12.00	2.05
12 in. pipe sewer.	Sand and gravel	12.00	2.97
12 in. pipe sewer.	Hard pan, dry	12.00	2.65
12 in. pipe sewer.	Hard pan wet	12.00	3.60
12 in. pipe sewer.	Rock	12.00	4.83
12 in. pipe sewer.	Filling	12.00	1.98
12 in. pipe sewer.	Sand, gravel and boulders	12..00	2.00
15 in. pipe sewer	Sand and gravel	12.25	2.98
15 in. pipe sewer.	Filling	12.25	1.75
15 in. pipe sewer.	Hard pan	12.25	3.35
20 in. circular brick sewer.	Hard pan and rock	12.67	5.20
24 in. circular brick sewer.	Sand	17 00	26.00
Average cost of building manholes, each			$36.06
Average cost of building catch basins, each			35.31
Average cost of building extra inlets, each			8.24

*In drains to curb line.
†In basin connections.

Examination for Laboratorian.—The U. S. Civil Service Commission announces an open competitive examination for laboratorian on Dec. 6 and 7, 1922. Vacancies in the Federal classified service throughout the United States, including the Departmental Service, Washington, D. C., at $1,200 to $1,500 a year, or higher or lower salaries, will be filled from this examination. The duties of appointees will be to assist in physical and chemical laboratories.

Relation of Quality of Water to Life of Service Pipes

Experiences at Milton, Mass., Described in Paper Presented Sept. 13 At Annual Convention of New England Water Works Association

By D. A. HEFFERNAN,
Superintendent Water Works, Milton, Mass.

In 1912, Milton, Mass., which like several other towns of suburban Boston, is supplied with water from the Metropolitan system, began to use exclusively for its services genuine black wrought iron pipe lined carefully with Rosendale cement in our own shop. Our couplings were lined with lead. The corporation tail piece was made into a lead gooseneck by means of a cup joint and the same method used for connecting with the service pipe. A. T. H. S. & W. cock was used at the curb line and a L. H. S. & W. cock in the cellar. All fittings other than the lead-lined couplings were of brass. About two years ago, complaints began to come in about poor pressure. Inspections revealed the results of violent galvanic action causing the eating away of the pipe at the threads inside the brass fitting and almost completely filling the latter up. Of course it has been known for a long time that two different metals or two like metals of different composition immersed in water, incite and are the victims of, galvanic action, to varying degrees, according to the metallic composition and the impurity of the water.

However, I admit that its danger had not been forcibly brought before me until then. Immediately we began to work to overcome the trouble, by using in the service, material on which the effect of the water would not be so disastrous. Our final result is to line all fittings and stops with lead so that no water comes in contact with any two metals other than lead and brass or lead and iron. We have been using this type of service in our installations for two years past and are gradually replacing the brass fittings in our old ones with a lead-lined malleable iron.

Corrosion of Services.—Other superintendents supplying their districts with water from sources other than the Metropolitan may have a different problem. In my opinion, the great majority of superintendents know too little of the quality of their water. Some, who have private supplies are careful that their analyses should show that it is fit to drink; but have they studied these analyses with a view to the action of the water on the pipe material? And have they tried to correct any fault it may have, or use the pipe material least affected, or both? If not, I am afraid that they will have their hands full when their services begin to fill.

Every superintendent should know that, while deep well waters contain little oxygen, surface waters are saturated with that gas and if the prevalence of algae is great they are often supersaturated. Carbonic acid gas, shown in analyses as coloring matter, means liberation of hydrogen ions, inducing corrosive action. Lead is soluble to some degree in all waters. It has been shown that a lining of tin, because of crystallizing in cooling, will not protect the lead. Why, then, does our State Board of Health permit the use of lead pipe in waters which easily dissolve it? We were required some years ago to forego the use of lead services because it was shown that Metropolitan water took up a certain amount of it. I cannot understand why other cities and towns using the same water still use lead services.

Electrolytic Action.—However, water containing impurities is not entirely responsible. The presence of these merely accentuate the action, through electrolysis. This electrolytic action is very similar to the simple electro-plating process. The difference of potential in the two metals induces the current. The presence of mineral salts increase the conductivity of the water, for, be it remembered that, common theory to the contrary, absolutely pure water is a poor conductor. If carbonic acid gas and oxygen are present in large quantities the attack of the water on the metal is more violent. Chlorine aids conductivity while alkalines retard corrosion. Generally speaking, soft waters are more corrosive than hard. By a study of their analyses superintendents may determine about what to expect from the waters they distribute.

Then there are some who, simply because their water is analyzed by the State Board of Health, think that it must be all right and let it go at that. The majority do not attach sufficient importance to the results of these analyses.

A short time ago, in line with my investigating, I ran across an interesting case. A resistance in Chestnut Hill was plumbed in certain parts with copper pipe in September, 1920. By March of the following year matters had got so bad that the owner of the house had the plumber who made the installations obtain analyses of several samples of the water. It seems that notice of the water was taken when bath sponges turned green. The analyses disclosed that the copper content ran up as high as 1.85 parts per million. Correspondence, examinations and analyses passed back and forth for a couple of months with suspicion gradually pointing to electrolysis. The telephone and Edison companies were asked to make some other arrangements with respect to the grounds on water pipes. Later, representatives of these two companies co-operated to the extent of changing their groundings to a point back of the meter.

A Method of Detecting Causes of Electrolysis.—M. V. Croker, superintendent of the pumping station, at Newton, Mass., was consulted. His contention was that the aggravation of electrolysis in and the resulting damage to service pipes could be laid to the telephone ground, street, railway stray currents and the Edison ground, mentioned in the order of their relative importance, the first being the worst offender, especially in instances of so-called divided ringing. He had constructed an insulator which was to be installed in the service pipe on the house side of the meter, which would prevent foreign currents passing that point. By its use Mr. Croker was able to establish the cause of the trouble.

This insulating device consists of exterior of non-corrosive metal in two sections. Upper and lower castings are insulated from each other through the medium of fibre at the flange and at the bolts. The interior consists of a tube of glazed porcelain through which the water passes, the porcelain being made water tight on each end and by leather washers or any other suitable material. A vent hole at top and bottom of casting allows dry air circulation between the proccelain and the exterior metal and also provides a means of determining if the porcelain is sealed tight on the end gaskets. The purpose of this insulating device is to offset the abnormal corrosion and encrustation of house plumbing due to the electrical grounding on service pipes of telephone, lighting, street railway leakages, etc.

The supposition that the water service line to the street affords the best possible ground is decidedly at variance with facts when the premises contain a hot water boiler or steam boiler with direct connection as a method of supplying heat. The tendency for the current to flow through house piping to the ground through these fixtures or laundry equipment or any object that has a large metal area next to mother earth or concrete. This applies in a great measure to the degree of conductivity of the piping: that is, copper, brass, etc. The insulation is placed on the water service on the riser immediately inside the cellar wall providing ample room, however, on the street side of nipple for the groundings already referred to, thus leaving the expensive house piping free from electrolytic action.

Wasteful Plumbing.—The present day policy of the average plumber seems to be to install fixtures that will deliver all the water possible with no regard for the ignorant consumer who has to pay the water bills. By this I mean that fixtures are installed by plumbers who do not consider the fact that a meter is on the service and that all the water passing through the meter must be paid for whether used or wasted. I believe that the most wasteful plumbing device being installed today is the low-down tank with cheap fixtures.

We have made a practice in our department when a customer complained of a large bill, of sending an inspector to visit the house and make an inspection of the fixtures. The excess amount of water used has been traced in 95 per cent of the cases to a leaky ball-cock or a defective valve in the closet tank. Very often an inspector can tell of a leak that has been repaired by the old water line in the tank, thus confuting the argument of the consumer that they "could not understand why they had such a large bill as there had been no leaks; they had been careful as usual of the water, etc."

The rubber ball valve installation is a very common one among unreliable plumbers who cater to a cheap class of trade and among the altogether-too-common builder for speculation. The valve may work properly for a short time, but soon becomes distorted and lies on the seat in a different position, causing seepage and finally leakage. In addition, the capacity of the automatic siphon tanks is about 7 gal., but most bowls require at the most 3 gal. to flush them properly. Furthermore, most tanks are permitted to fill to full or three-quarter capacity. This is an unnecessary waste of water. If 3 gal. will flush adequately, why use 6 or 7? I estimate that at least 50 per cent of the water supplied to these tanks is wasted through improper tank fittings.

Plumbing Regulations Not Adequate.—The amount of money being invested annually in plumbing supplies and fixtures is increasing rapidly and even now reaches millions of dollars. The regulation of plumbing has not kept pace with the increase in fixtures, so that, at present, we have on the market certain appliances which are worse than useless; they are a needless expense.

Several years ago with the scramble for cheap plumbing, someone conceived the idea that if a hot water boiler could be made to withstand ordinary street pressure, it might be connected under direct pressure to the supply pipes, eliminating considerable piping and the cost of a tank on an upper floor. At the same time no inconsiderable amount of space was saved. Now, every cheap job of plumbing includes a pressure boiler, usually galvanized iron, frequently built into the wall in some almost inaccessible position. Several problems have presented themselves as a result of the installation of pressure boilers. A relief valve must be provided, and a vacuum valve. With the present quality of the water, how can we prevent the action on these valves which prevents their proper operation? The law in most municipalities insists on the use of these two valves. Theoretically and practically, they are necessary, but when called upon to do their duty after corrosion has had its day, theoretical action is all the valves have. More than half the time they stick or leak.

The extensively used automatic devices for heating water and the faulty manner in which they are connected should be controlled by law. Galvanized boilers are being used with brass connections, ½-in. galvanized pipe is used for the supply often coupled with brass fittings. We know what a connection of brass to iron will do in most waters and how quickly ½-in. galvanized pipe will fill up with rust.

A Dangerous Practice.—In some towns near Boston the waterworks superintendent insists upon the use of a check valve in the supply on the house side of the meter to prevent the backing of hot water through the meter if the pressure boiler becomes super-heated. It often happens, I am told, that there is no relief valve in the system or that corrosion has eliminated the possibility of its proper operation. The result is an explosion with damage to property and danger to life. I think it is a mistake to place the cost of placing the rubber piston and warped cylinder of a meter above the damage caused by an exploded boiler. The State should prohibit absolutely the installation of check valves on supply pipes unless there is a by-pass with reversed check valve around the meter.

In closing, I wish to place special emphasis on two points:

(1) Something must be done to diminish the action of the water on piping materials, either through purification of the water (preferably filtering), or by a study of the action, if any, caused by wiring grounds, or both.

(2) That a state board for the regulation of plumbing should be constituted, which would forbid the use of some wasteful devices and regulate the use of others. This would not only greatly benefit the house owner, ignorant of such matters, but would also tend to decrease the per capita consumption a great deal and thus probably postpone for some years the necessity for new water supplies.

Method of Constructing Intake Line with Spiral Riveted Pipe

An interesting job of river intake line construction was completed recently for the Bemis Bros. Bag Co., at Peoria, Ill. The edge of the channel of the Illinois river, at this location is about 1,500 ft. from the shore line at low water. The channel bank is steep and there is 22 ft. of water about 20 ft. from the edge. From the edge of the channel to the shore there is a very flat, shelving bottom averaging 3½ ft. to 4 ft. of water, mud and silt. This part was originally a corn field before the canal of the Sanitary District of Chicago was emptied into the Illinois river.

The pipe for this line is 14 in. asphalted extra heavy American spiral riveted pipe in 30 ft. lengths. The line is 1,500 ft. long from the concrete pump pit to the swivel elbow. On the swivel elbow there is one length extending down stream with a standard 14 in. strainer on the end. This end is bucked up so it is about 5 ft. off the bottom. The strainer end has a 40 ft. length of chain fastened to it. This chain is laid on the bottom parallel to the pipe line toward the shore. In case of trouble from choked suction it is possible to raise this strainer, swinging it around on the swivel elbow to the surface and clean it.

Intake Line Just Before Sinking.

The first step in the preparation to install this line was to build two barges 4 ft. wide by 12 ft. long and by 2 ft. deep. These barges were lashed together by 4x6 in. timbers which held the boats 30 in. apart and allowed them to rock together in case of rough water. On each boat was fastened an A-frame with a beam across the top of the A-frames. This beam had an eye bolt in the center of it for hanging a chain hoist on. Two sets of bucks were built. These bucks have pipe across them to slide the intake pipe on.

The 14 in. pipe came on two cars and as soon as received was rolled and slid to the river near the two bucks, which were placed on the line from the pump pit to the edge of the channel. The end of the first length was sealed with a gasket and ¼ blind flange. This end was then chained to the 4x6 in. cross beams on the barges. The scheme then was simply one of rolling up a length of pipe, putting in a gasket and bolting onto the end going out. The shore end was then pried up and a pipe roller put under and the whole line shoved out. The pipe floated like a cork. If there had been good weather the job could have been completed in 4 or 5 days. However, squally weather delayed the work and made it necessary to anchor the floating pipe.

When all the pipe was installed, the swivel elbow, one length of pipe and the strainer, all bolted together, were taken out in a boat and fastened on. The shore end of the pipe line was then bolted to the suction connection of the pump outfit, and a joint sprung up at this end and cracked for a vent. The river end was then allowed to sink by lowering with the chain hoist. The whole line then gradually sunk to the bottom, beginning at the river end. Two 1 cu. ft. blocks of concrete joined by a chain were put on the pipe line every 100 ft. to act as anchors until the line beds itself in the mud.

In the pump pit the company have a 10 in., 2,500 gallon per minute horizontal split case centrifugal pump, made by the American Well Works, direct connected to a 40 H. P. G. E. motor. Also as protection to the pump they have an Elliot twin strainer ahead on the suction. This pump pit it 13 ft. square and 21 ft. deep. There is a 25 gal. per minute automatic pump to take care of seepage.

The intake line was constructed under the direction of Frank O. Agner of the Bemis Bros. Bag. Co.

Tight Flexible Joints for Submarine Pipe Lines

Research Narrative of Engineering Foundation.

By ALFRED FLINN.

Formerly Deputy Chief Engineer Catskill Aqueduct.

Nature has made Staten Island a part of New Jersey, but man attached it to New York City. Consequently, when demands for water from the public supply exceeded resources on the island, Catskill mountain water brought 120 miles had to be gotten from the nearest part of the "Greater City"; but The Narrows, two miles wide, the deep entrance to the harbor, lies between, with fast-flowing tides and heavy commerce. Many kinds of pipe and methods for laying them were considered. A heavy 36-inch cast-iron pipe with ball and socket joints was selected. Conditions "too numerous to mention," precluded effective employment of divers.

The problem narrowed itself to making a pipe which, beginning at Brooklyn, could be put together, link by link, like a chain, and "paid out" from a barge into the water to sink to the bottom of the derdged trench as the barge was moved, a few feet at a time, across The Narrows. The joints must be strong, but quickly made. They must be water-tight when made and so remain in spite of the bending and pulling to which they would be subjected as the pipe line was "paid out" and settled to its bearing in the truench.

The inside of each socket was turned and polished accurately to a spherical surface. A narrow band on the opposite end, or spigot, of each pipe was turned to a spherical surface to fit the inside of the socket. So far only careful foundry and machine work was required. How should the joint space between the spigot and socket be filled?

Molten lead is the common material for water pipe joints, but lead shinks appreciably as it cools. Ordinarily this would be remedied by calking, i. e., making the lead flow slightly after it is cold by blows from a hammer on a steel calking tool, thus filling the space tightly. Calking, even with powerful pneumatic hammers, failed to cause the lead to flow far enough back in the flexible joint to keep it tight after bending a little. "Lead wool," calked in, a strand at a time, was tried; very tight joints could be made, but they would not bend readily enough and besides consumed too much time. Several alloys of lead, which like type metal would swell slightly on cooling, were tried, but none proved suitable. Other schemes were tried.

One day, while experiments on full-sized pipes were in progress in a shop near Philadelphia, the engineer in New York had a long distance call; would he permit sixteen ½-inch holes to be drilled through the socket of the pipe in a ring around it? A foreman had suggested that such holes be drilled and threaded so that slugs of cold lead could be forced in with strong steel screws until the shrinkage space was filled. His father, as superintendent in a refrigerating plant, made leaky joints in ammonia pipes tight by drilling small holes in the couplings and forcing bird shot in by means of "set screws." Permission was given at once. A trial showed that the method had merit. By long and careful experimentation details were perfected.

Two rows each of sixteen holes ¾-in. in diameter, were drilled around the socket of each pipe. After approximately 250 pounds of lead had been cast into each joint on the barge, 144 lead slugs 1¾ inches long and 9/16 in. in diameter (total weight 26 lbs.) were forced into the shrinkage space by means of steel screws operated by a special tool, and with them flake graphite and grease, as a lubricant. At first each joint was tested as made with water under 100 lbs. pressure, but these joints were so uniformly tight that tests were discontinued. After the pipe line had been completed, which required two seasons with a winter interruption, a 40-day test under 110 lbs. pressure showed a leakage of only 3 quarts per minute from more than 800 joints.

Removal of Cemeteries from Reservoir Sites

The area condemned by the city of Providence, R. I., for the site of the Scituate Reservoir of its new water supply included 101 farm cemeteries and a community cemetery near Rockland containing about 75 lots. How the removal of these cemeteries was handled is described by Mr. Frank E. Winsor, Chief Engineer of the Water Supply Board of Providence, in a paper presented at the last annual convention of the New England Water Works Association.

The total number of known bodies was 2,308, which number has been materially increased by the discovery of unmarked graves as the work of removal progressed. About one-half of the farm cemeteries are so far distant from the flow line that their removal is unnecessary although further burials have been prohibited.

A new cemetery known as the New Rockland Cemetery was established upon a sandy knoll about ⅝ mile distant from the flow line of the Rockland arm of the reservoir and 6 miles distant from the dam. The removal of bodies was begun in September, 1918, and this work was practically finished in July, 1922. The development of the cemetery, including drives, etc., was done by forces in the direct employ of the Board, as was also nearly all the work of removal of bodies thereto, moving and resetting headstones, monuments, etc. The new cemetery was laid out and the plan filed in the records of the town where located. In consideration of a release to all right, title and interest in the old ground, parties interested are given a deed to a lot sufficient for their needs in the new grounds, and the bodies in which they are interested, together with headstones and monuments moved thereto. Some of the rules of the new cemetery are as follows:

All work in the old and new cemeteries shall be done only by parties previously approved by the city.

All lots shall be bounded by permanent concrete monuments provided by and set by the city, such monuments to be 5 in. square and 20 in. long.

There shall be no curb stones, iron or stone fences or close hedges permitted.

No foot stones will be permitted and foot stones in existing grounds will not be brought to the new grounds.

Headstones shall be set at least as permanently and satisfactorily as in present grounds.

Field stones without lettered inscriptions marking graves in existing grounds will not be moved to the new grounds.

Suitable records shall be kept showing the position of all unmarked graves in the new cemetery and the locations from which they were removed.

The work of removing cemeteries is practically complete, there having been 1,598 bodies removed, of which 1,448 have been moved to the new cemetery, the remainder having been moved to lots provided by parties interested, in other cemeteries, generally in the state of Rhode Island. The grounds have been maintained to date by the city and the approximate cost of the work including bodies moved to other cemeteries, has been as follows:

Maintenance $2,800.00; received for original interments $500.00; net cost of maintenance $2,300.00; development of new grounds $15,800.00; moving bodies, head stones, monuments, etc., $17,100.00. Total $35,200.00. Cost of land $1,700. Total cost, including land, $36,900. Cost per body moved from old grounds $23.09. The above costs do not include administration, engineering, or fencing which may later be necessary.

Texas and New York Have Largest Allotments of Federal Aid.—Texas and New York are the states which receive the largest allotments of Federal aid for highways, which is distributed on the basis of population, area, and mileage of rural highways.

Railways and Excavation Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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The Future of Urban Transportation

Plans for transportation within our cities in the years to come demand all the attention which they can be given. Problems multiply and conditions change at a bewildering rate, but whereas we cannot justly blame our grandsires for failing to foresee most of the changes from their comparatively static conditions, we of today shall be grossly to blame if we saddle our children with improper and inelastic systems, all at great expense to ourselves and through long term bond issues, to them also.

The science of city planning is doing much to help the situation, and we cannot but wonder how many engineers appreciate the credit that is due the architects, as the ones to whose efforts chiefly the present development of this essentially engineering science is due. Of necessity the street system is the foundation of any city plan, and street plan, street design, and means of transportation are all interdependent parts of a single great mechanism for the service of man. Hence the vital concern of the transportation engineer with city planning.

For the street railways the outlook in general is not bright. Private and public automobiles have introduced a disastrous competition once undreamed of, and a public hostility, sometimes deserved, but more often due to the malicious propaganda of demagogues and the inevitable friction from so intimate a thing as personal carriages, has resulted in much damaging legislation. The latter difficulty is on the way to improvement if not to complete cure, but the former is permanent.

That the freely moving omnibus will do away with the railway street car we have never believed, but it has already brought new conditions and operating limitations of prime importance. The reported ruin of the street railway business of London is interesting and also instructive; but instructive in detail only, for there is no counterpart to the London situation. Even Boston, with streets the narrowest and most irregular of all cities in this country, has a problem very different from that of London.

In municipal districts of comparatively sparse settlement the bus will take the place of the railway and will be welcomed by the street railway interests as relieving them of duties not to be performed economically with their equipment. In fact the railway companies may well turn to the development of a bus business on their own account for the service and development of many outlying sections. In the busy areas of large cities the outcome is not yet clear, for though where their operation has been permitted the jitney busses and some other types have cut heavily into street railway earnings, but profits appear to have been scant, and it is more than possible that no form of competitive vehicle can render a service as satisfactory in many ways as that of the street cars. For medium haul traffic—that is for movements between business or industrial centers and districts at some distance yet not far enough to be classed as suburban, we can see no sign of the street car's doom. Busses and private cars have taken away considerable of the profitable short haul traffic, and have cut in on the medium haul, but it seems altogether probable that the volume of business and the varying requirements of traffic will leave a place for the street cars as far into the future as we can see, but with profitable operation more difficult than it has been in the past.

The elevated is admittedly offensive to almost every esthetic sense, but its practical usefulness is such that most old elevated lines will be retained for a long time and more will be built in spite of Mayor Hylan's declamations on scrapping them. Improvements in appearance and reductions of noise are possibilities which should well repay systematic study.

The subway is a blessing to great cities, but an expense which only the wealth and business of great cities can support. Unfortunately a proposed subway is often made a political football in spite of the fact that the problem is susceptible of fairly close economic solution. Subways undoubtedly will be built in increasing numbers.

We have spoken of well known transportation agencies, for it is to the development and improvement of these that we must look primarily in planning for the future. To the possibilities of other agencies we must be constantly alert, but we cannot spend our time in dreaming of what may be done with monorails and airships when definite action is necessary and such devices remain unperfected for our purposes. If in addition we preserve a broad vision of future possibilities in traffic development, and as much elasticity in our plans as is permitted by conditions we shall have done our duty.

Of one apparent though undemonstrated opportunity we would speak briefly. We refer to the two level street. Of course subways and elevated railways are types of grade separation, but we refer to such developments as elevated ways for pedestrians, slow and fast vehicular traffic at different levels and other departures of like character. Solutions by such means are not easy, but they probably afford the most promising opportunities of the time beyond those things with which we are familiar in some form or other.

The Toll of the Grade Crossing

The terrible record of dead and maimed in collisions of trains and automobiles during recent months is abnormal and not in the least likely to be maintained. We are passing through one of the cycles of accidents which have bred numerous superstitions but which need as little supernatural explanation as do the changes in the price of corn. The present cycle will end, and accidents will again occur at their more or less normal rate, but that "normal" is too high to permit of its acceptance as a matter of course.

It is no small irony that such a record should be established toward the end of a season in which the railroads have made an especial effort to prevent crossing accidents; and the fact shows the difficulties of effective education in such matters. However, this is not to say that education is useless. Admittedly slow and incomplete as its effects are, it is reasonable to think that its value far exceeds its cost.

Without doubt most crossing accidents are the fault of the auto drivers rather than of the railroads, but the railroads are not always blameless, and in any event they have a vital interest in the matter. It is significant to note that while all sorts of people have been meeting disaster at the crossings, by far the greater number of the drivers have been of unthoughtful types. Young people not yet possessed of enough discretion to warrant their operation of powerful and swift machines; workmen without either training or experience which would develop careful habits; drunken men; these, if we recall the newspaper accounts correctly, have made the majority of the drivers of "death cars." Such will continue to drive automobiles, and such also are the hardest to reach through any process of education.

Complete solution of the problem there is not, for the elimination of all grade crossings is an economic impossibility. As during the war the submarines were worsted not by any single weapon or device but by a combination of means, so the grade crossing menace must be reduced by a variety of expedients. Crossing elimination will continue indefinitely, the cases being taken up substantially in the order of their degree of menace; gates and watchmen will be placed at numerous points where the cost of grade separation is, for the present at least, prohibitive; obstructions to view will be eliminated, involving in some cases the removal of considerable quantities of earth—a practical, but largely overlooked and neglected expedient up to the present time; automatic signals will become universal even in remote sections; laws holding auto drivers to a more rigid responsibility will be passed, and we hope enforced as effective warnings; and the campaign of education will be continued perhaps perpetually.

The highway commission of Wisconsin has an engineer co-operating with the railroads in the study and solution of its crossing problems, and it is to be supposed that other states will follow this example, from which much is to be hoped.

"They" and "We"

Editorial in American Machinist.

In discussing the relation of sales management to industrial engineering at the convention of the Society of Industrial Engineers in Detroit, Norval A. Hawkins brought out a point that is as valuable as it is simple and concise. He said that when the salesman refers to the firm that employs him, he always says "we," while the average workman refers to his employers as "they," and that when the employers get that defiant "they" changed to a co-operative "we," better results will be obtained both as to quality and quantity of product, and the differences between the employer and employe will begin to fade. Mr. Hawkins also said that in the institutions with which he has been connected he has always tried to make the commonest laborer feel that he (the laborer) is a salesman, and that the success of the institution depends just as much on him as on the salesman who delivers the finished article to the ultimate consumer.

A world of thought is contained in Mr. Hawkins' remarks. The difference between "we" and "they" is the difference between co-operation and indifference, and even, in some cases, atagonism. When the employe is brought to realize that his own job, as well as everybody else's from the general manager down, depends on the success of the firm; when he is satisfied that his working conditions have been improved as far as possible; when he is convinced that the firm is paying him the highest wages that will allow a fair margin of profit; when he has been shown that every man who has any part in the manufacture of the product is a salesman, because future sales depend largely on the quality of the work that passes through his hands; when he has learned that he is getting his share of the profits just as surely as any stockholder or officer of the company —then he will discard the "they" when referring to the company or its product and say "we."

Those who are wise will lose no time in doing what they can to hasten the coming of such a day in industry.

High Cost of Selling Machines to Railroad

Editorial in Railway Age.

Manufacturers frequently complain, and with much justification, that it costs more to sell shop machinery and equipment to railroads than to other industries. In fairness, therefore, the railroads ought to be willing to pay more. One manufacturer writes as follows: "On many lines of machinery of a new or improved type, railways should properly pay a higher price than industries because, over a long period, it is necessary to spend far more time and money to introduce such machines than it requires with the general trade. Railways figure that they are competing with no one in shop work and, therefore, do not keep on their toes in trying to cut down shop costs." Even when manufacturers can prove an operating economy for a machine, the report is that they always secure a much larger percentage of orders from the general trade than it is possible to secure from the railways. This is a severe indictment of present railroad methods and to the extent to which it is true, present methods should be corrected. It has been suggested that valuable results would follow if the responsibility of the shop managements in the way of reducing costs could be increased, at the same time granting them more power in installing efficient equipment and methods. At present, railroad supply manufacturers are compelled to interest shop foremen, higher mechanical department officers and purchasing officers in all new equipment, convincing these officers that the advantages claimed for the equipment are actual. The cost of this educational and demonstration work is high and must come out of profits on the machines manufactured. In the long run increased selling costs are added to production costs and form a tax paid by all purchasers of machine tools.

How to Secure Better Appreciation of Engineer's Services

To the Editor: Referring to Mr. Van Auken's letter in a recent issue of Engineering and Contracting under the caption, "Do Engineers Think?" as a representative of the rank and file of the army of engineering, to wit, an employed engineer, I am impelled to offer an observation anent the the writer's implication that engineers as a class do not think; a criticism of his recommended method of improving the "fitness" of engineers, which in my opinion nullifies partially the intent of the article: and lastly, what I believe to be a constructive suggestion to secure a better appreciation of the service which engineers render.

In the first place, the inference that engineers, on the whole, are any less capable of thought than other groups of professional specialists is an impeachment in large part due, not to the engineers themselves, but to the layman's conception of an engineer, towit; one, who by schooling has absorbed a few set ideas, and who is a skilled mechanic in the use of his instruments (slide rule, handbooks, etc.), which, if he has learned his "trade" and manipulates them properly, will give him the required results with automatic accuracy, verging on the supernatural. It is surprising to what an extent varying shades of this conception prevail, and as a result, there is an absolute lack of appreciation of the imagination, study, and continual process of balance and compromise to meet and overcome the obstacles of even the most simple engineering problem. The regrettable truth of this condition is brought home, in the fact that engineers are very often dependent for the practice of their profession upon the decisions of persons holding this view, who give the preference to the obvious "rule of thumb" engineer, with his "exact" results, over the engineer with sufficient vision and engineering conscience to qualify the limitations on which his results depend.

This idea may be accounted for, since the engineer is distinct from other professional men, as the lawyer, doctor, etc., in that he deals with forces and material things, as distinguished from human beings. In the popular sense, the latter require analysis, whereas, in dealing with concrete things, the engineer manipulates them by established formulas, requiring little else than a college diploma to operate, from the layman's viewpoint.

The question then, might be more aptly put, "Do the mass of people think?" with the inevitable answer, "Some do and some don't. The reply would be equally applicable to such a question relating to "students," "engineers," etc., the percentages pro and con varying within the limitation of such experiments as the trained psychologist might devise. In justice to engineers, therefore, we must recall that in the so-called intelligence tests (which, though open to question when applied to individuals, have been valuable in rating groups), the scores made by engineers, as a class, have paid high tribute to their mental discipline.

Referring to Mr. Van Auken's remedy for the "thoughtlessness" of some engineers with a quantitative recommendation for "a minimum requirement for remaining in service" of the annual consumption of "four technical books," "one weekly," and the membership in "one association," it is difficult to see what could be gained by such a procedure. As a suggestion from chief to assistant, the items are invaluable, and the employer will in many cases find himself anticipated by the wide-awake subordinate engineer, but as a "requirement to remain in service," the idea smacks strongly of that type of engineering thought best described as "rule of thmub," which, if carried to extremes, would justify the conception of the employed engineer as a "slide rule mechanic."

That there should be such a condition as that of "an employee sure of a steady promotion without regard to his fitness," is unfortunate, but it would not be ameliorated in the slightest degree by any such "requirement." History and many bloody wars have demonstrated the fallacy of attempting to stimulate thought by anything resembling legislation or compulsion. Under such a theory of technical literature dictatorship in any organization, the engineer would be still more open to the query, "Do engineers think?" with the logical reply, "No, they let their employers do it for them." Carried further, it is not difficult to imagine the subordinate "boning" at the last moment for his quarterly report, a picture reminiscent of student days.

In conclusion, I do not believe that engineers are relatively low in thinking capacity in the discharge of their duties, nor do I believe that either chief or assistant will subscribe to Mr. Van Auken's "minimum requirement" as a remedy for those who are. A real field of effort, however, is to be found in educating the general public to an understanding of the problems confronting engineers in their ordinary work. This might be done by the publication of a series of syndicated articles in the daily press under the auspices of an engineering society; the articles to be of an elementary scientific nature describing the properties and variations of materials, their application, and simple, non-technical outlines of the problems and methods of solution attendant upon engineering features. Such reading matter would be an eye-opener to "Constant Reader" as to the nature of the training and preparation necessary to accomplish such work. The interest of the reading public would instill in the young engineer a pride for his chosen calling, and be a constant spur to him to stay "fit" for the sake of himself and of his professional associates.

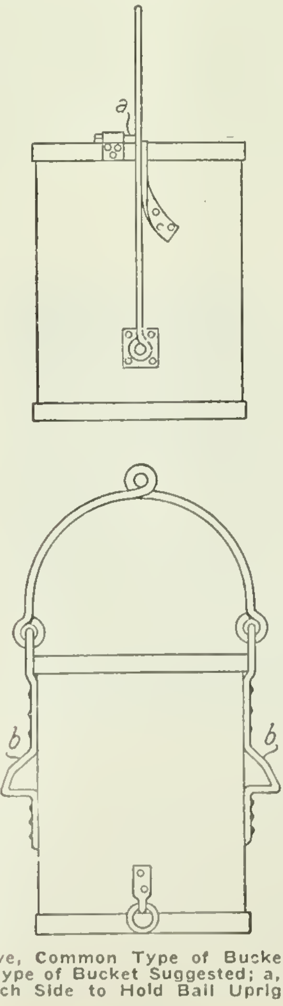
ERIC FLEMING.

New Brunswick, N. J.

Buckets for Shaft Sinking

The type of bucket shown in the upper part of the illustration commonly used in shaft sinking, is a source of danger, according to a recently issued bulletin of the U. S. Bureau of Mines on "Safe Mechanical Equipment for Use in Shaft Sinking." Such a bucket is suspended from a bail, which is attached to the bucket below its center of gravity by trunnions or pivots, and is prevented from overturning while being hoisted by latches on the side of the bucket. Should the latches become bent or be jarred loose by continued use, or should the bucket catch during hoisting and the latches bend enough to clear the bail, the bucket will overturn and its contents will drop on the men working at the bottom of the shaft.

A much safer bucket, states the bulletin, is one that has the bail so pivoted at or near the top that it will retain its upright position by gravity. Such a bucket may be emptied into a dump chute built into the head-frame by means of a "bull chain" hooked into the ring at the bottom of the bucket and so arranged that, as the weight of the bucket is transferred from the hoisting rope to the bull chain, the bucket is carried from its position over the shaft to one over the dump chute and then overturned. The bucket may also be lowered on a dumping truck which has slotted posts to support the bucket, with the slots holding the trunnions, and may be kept upright by a suitable latch while the truck is being pushed out to the dump. Either method of dumping requires little more time and effort than dumping by the ordinary method, and is much safer.



Above, Common Type of Bucket; Below, Type of Bucket Suggested; a, Latch on Each Side to Hold Bail Upright; b, Lugs.

Notes on Operation of Electrified Line of C., M. & St. P. Ry.

Some interesting information on the operation of the electrified main line of Chicago, Milwaukee & St. Paul Ry. was given by Mr. A. W. Baker of the engineering department of the railway in a paper presented last April before the Minnesota Section and Student Branch of the American Institute of Electrical Engineers. The notes following are abstracted from the paper:

The electrification of the 443 miles of main line of the Chicago, Milwaukee & St. Paul Ry., from Harlowton, Mont., to Avery, Idaho, and 209 miles from Othello, Wash., to Seattle and Tacoma, makes this the longest and one of the most important electrifications of main line railroad in existence. The conditions on the 443 miles of the Missoula and Rocky Mountain divisions are especially severe. Grades run as high as 2% for a distance of 21 miles and 1% for 49 miles. Curves are often as sharp as 10 degrees. Tunnels are frequent—there being 36 in these two adjacent divisions. Weather conditions are extreme, including heavy snows and temperatures often reaching 40° F. below zero. The temperature conditions on the Coast division are not so bad but the grades run as high as 2.2% for 17 miles.

Why the Line Was Electrified.—The reason for electrifying was to overcome the difficulties encountered in the operation of steam locomotives under the above conditions. The chief difficulties were the inability of steam locomotives to haul heavy trains over the steep grades with sufficient speed to keep the track properly open for traffic in the opposite direction. Cold weather greatly aggravated this condition and tunnel operation was unsatisfactory; also the strain on air brake equipment going down steep grades required operation at slow speeds.

Characteristics of Electric Locomotives.—The chief characteristics of electric locomotives that enable them to meet the conditions of traffic on this line are as follows:

(1) High overload capacity as compared to no overload capacity of the steam locomotives.

(2) Greater power rating for same weight due to receiving energy from a source of ample power.

(3) Ability to return energy to the line by regeneration, thus regulating the speed on down grade and keeping the air brakes for emergency and full stop use.

The first characteristic often enables one electric to do the work of two equally powerful steam locomotives in pulling a train over a section of track requiring two steam locomotives for a short time. The greater power rating means that an electric locomotive having the same weight as a steam locomotive may be designed to exert its tractive effort at a much higher speed, or to haul a greater trailing load at the same speed. Regeneration saves brake shoes and wheel tires, increases safe operating speeds down grade, and chalks up a credit in generated power amounting for these divisions to about 12% of the total energy used.

The 443 miles of line is supplied with power by eight connections to the Montana Power Company's 100,000 volt, 60 cycle, three-phase lines. The railroad company has its own high tension line along the railroad for tying in and supply power to 14 sub-stations of 59,500 K. W. total capacity where the energy is converted by motor generator sets to 3,000 volts d. c. Electric service was started in December, 1915, and since early in 1917 full electric operation has been in use.

The first electric equipment consisted of 30 freight and 12 passenger locomotives of 288 tons weight, built by the General Electric Company. The passenger locomotives had a lower gear ratio and carried oil burning boilers for heating the coaches. These have since been re-geared for freight service and superseded by 10 specially designed 283-ton Baldwin-Westinghouse locomotives. Four 70-ton switchers are also in service.

The energy for the coast division is purchased from the Washington Water Power and the Puget Sound Traction, Light and Power Companies. There are eight sub-stations of 28,000 K. W. total installed capacity. Sixteen freight locomotives are now in service on this division leaving 26 for the other installation. The passenger traffic is handled by five bipolar gearless General Electric locomotives specially built for heavy passenger service and weighing 260 tons each. Full electrical operation has been used here since March, 1920.

Comparison of Electric Locomotives.—A comparison table of data on the electric locomotives follows:

Class	Freight	Passenger	Passenger	Switch
Builder	G. E. Co.	G. E. Co.	W. E. & M. Co.	G. E. Co.
Type of drive	Twin gear	Gearless	Full spring	Solid gear
Number	42	5	10	4
Wheel arrangement	44-4-4-44	24-8-8-42	462-264	4-4
Length	112 ft.	76 ft.	79 ft 10 in.	41 ft. 5 in
Weight, tons	288	260	283	70
Weight on drivers	225	229	184	70
Diameter of drivers	52 in.	44 in.	68 in.	40 in.
Number of driving motors.	8	12	6 (twin)	4
Continuous rating	3,000 hp.	3,200 hp.	3,400 hp.	475 hp.
Tractive effort, tons	35.35	21	24.5	7
Speed, m. p. h.	15.9	28.4	26	12.8
One hour rating	3,440 hp.	3,500 hp.	4,200 hp.	670 hp.
Tractive effort, tons	42.25	24.25	33	11.2
Speed, m. p. h.	15.25	27.1	23.8	11.2
Tractive effort, starting	67.5	61.75	55	21
Tractive coef., starting	30%	25%	30%	30%

The freight locomotives haul a 2,500 ton trailing load up a 1% grade at 16 m. p. h. On 2% grades the load at first limited to 1,250 tons but has been increased to 1,400 tons. The passenger locomotives will haul a twelve car train weighing 960 tons up a 2% grade at 25 m. p. h. and will exceed 65 m. p. h. on tangent track. Field control is used in connection with motor arrangement to secure more running speeds.

Cost of Electrification.—The cost of the electrification is important from a financial standpoint although in this case it was small in comparison to the cost of building another track for steam operation.

The double 4/0 trolley line cost $8,390 per mile, transmission line $2,360, sub-stations, $6,030, and other costs brought the total up to $17,579 per mile not including locomotives. The latter cost $122.500 each and $37,700 for the switching type. The cost of the Coast division electrification in 1918-19 ran about 50% higher.

Maintenance costs on the locomotives were 8.21 ct. per locomotive-mile in 1916, 9.62 cts. in 1917, and 10.87 cts. in 1918.

The traffic data for 1918 shows a combined freight and passenger movement with 33.2 watt-hours per ton-mile. Without regeneration of about 14% this would be 38.6 watt-hours per ton-mile.

The entire electrical demand is under the control of a load dispatcher who can reduce the sub-station voltage and thus lower the train input by reducing the speed. This is done at times in order to keep the maximum demand for power down to a contract value. This gives a load factor of about 53%.

Electric Locomotive Performance.—The performance of the electric locomotives has been very satisfactory. Minor defects have been corrected as they developed. With steam operation freight locomotives made an average distance of 80 miles a day and passenger locomotives 100 to 110 miles with a maximum of 250 miles per day. Under electric operation the freight locomotives regularly make 220 miles and the passenger locomotives 440 miles per day. Steam divisions have been converted into two electrical divisions, with much less repair and maintenance work. Short inspections are made at division points and complete inspections every 5,000 miles. The maximum performance of a passenger locomotive was 12,000 miles in a month. On one who is familiar with steam operation these figures will speak loudly in favor of electric locomotives.

Other advantages that may be briefly mentioned. In cold weather the electrics are even more powerful than in summer and have been found able to buck the snow drifts with apparent ease. They often make up two hours of time lost on the adjacent steam divisions. They pull without seeming effort due to the absence of the puffing exhaust, and their power is limited mainly by the strength of the draw bars in the front cars. They effect a saving of about 300,000 tons of coal and 4,000,000 gallons of oil per year. There is no stopping for coal and water and the total ton-miles of traffic is about 10% less due to the absence of company coal, the empty coal cars and engine tenders.

The electric locomotives have greatly increased the traffic capacity of the road and have practically eliminated the mountain grades.

Light, Compact Double Drum Turbinair Hoist for Use in Tunneling and Other Work

A double drum turbinair hoist designed especially for hauling rock or ore scrapers, either on the surface in contract work or underground in tunneling or mining, has been brought out by the Sullivan Machinery Co., Chicago. In this hoist, the turbinair motor, in its casing, is supported on a central standard with a broad frame or foot, and supplies power to the two hoisting drums, each 10¾ in. In diameter by 5⅛ in. face, which enclose the motor. A driving pinion at each end of the motor casing engaged an internal gear in each drum shell. Air is admitted at a central inlet port. The two drums are controlled independently by friction clutches and band brakes. The clutches are at the outer ends of the drum and the brake bands and handles at the inner ends. By this method either drum may be operated separately or both may be thrown into gear at the same time. In "slushing" work the live or hauling rope is attached to one drum and the tail rope or return rope to the other drum. By means of a suitably placed snatch-block or arrangement of sheaves, the tail rope is paid off the second drum as the load comes in on the first and when the scraper has been dumped, the process is reversed, the clutch being thrown out on the live rope drum, and in on the tail rope drum to haul the scraper back to the loading point. The hoist weighs only 555 lb. or about 85 lb. per horsepower, is 29 in. long by 15 in. wide and stands 18½ in. high. Each drum holds 225 feet of 5/16 in. wire rope. Either drum is capable of lifting 2,000 lb. dead weight vertically, with 76 lb. of air pressure at a speed of 110 ft. per minute. Sufficient air can be supplied the machine through a ¾ in. hose line to develop the machine's rating of 6½ h. p. The hoist may be used for other work within the capacity of the machine as for example on boom derricks, where one drum is used for hoisting the load and the other for operating the boom.

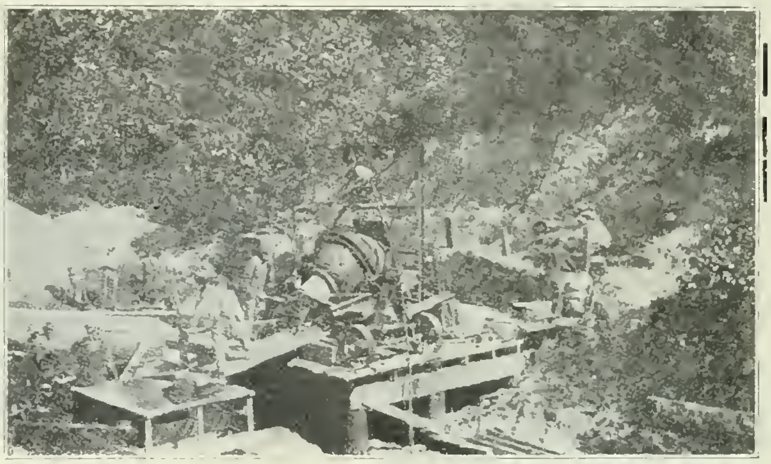
Labor Saving Devices for Railway Work

Tools, Equipment and "Kinks" That Have Proved Useful in Routine Bridge and Building Work Described in Committee Report at Recent Convention of American Railway Bridge and Building Association.

In the opinion of operating officers today the railroad problem of the future has changed from one of increased speed to one of greater economy in operation and maintenance. Gustav Lindenthal, in a recent article entitled, "What Is Ahead in Transportation," said, "We are not so much in need of wonders of speed as of wonders of economy. . . . . This is the age of waste prevention. That is the next phase of transportation. We have to find a better dollar's worth. What we shall discover within these next 10 or 20 years is not new methods of transportation but how to use the methods of transportation we already have."

While the committee has tried to put forward those ideas which appear new and valuable to the majority of railroad bridge and building men, it nevertheless realizes that to use more efficiently the materials and machinery we already have may prove the germ of the greatest saving. With this in view, the outline as sent out contained suggestions regarding as many every day things as could be thought of at the time and did not make any great attempt at the unusual. The consideration of labor saving devices by this association was probably influenced by the abnormal conditions under which most of the railroads are working at the present time. In some cases economic conditions have forced drastic reductions in bridge and building forces. The combination of current maintenance, delayed construction, reduced gangs and restricted working hours, has taxed the efforts of the bridge and building men to maintain the structures in their charge. The introduction of labor saving devices must, to a certain extent, offset this loss of man power.

Insufficient attention is paid to labor saving devices or those that increase output. It is the opinion of the committee that it would be a big step in the right direction if each individual railroad was to appropriate a sum of money annually as an experimental fund with which to try out new equipment or ideas that appear to have substantial merit. The experiments should be made under actual working conditions on a strict dollar and cent basis, by the men who would use the equipment in actual practice. The manufacturers of the equipment should share the expense with the railroads as their interests are mutual to a certain degree. No initial investment should be made in any labor saving device until it can be shown that it will produce a saving or will solve some particular labor problem. The chief difficulty in the way of providing and using labor saving devices where considerable investment is involved, is that economies are not always secured unless the device is kept in constant use. Keeping it in constant use is a difficult matter, because of the fact that points at which its use is economical may be widely separated or present themselves simultaneously. It is important to decide whether theoretical or actual economies are realized, also whether such equipment should be supplied for each gang, or for alternate gangs or be kept at division headquarters. The distribution of equipment and labor saving devices should be definitely under the direction of the division officers so that actual conditions in that locality may be given the proper consideration.



Concreting Plant for Replacing Floor of ½-Mile Tunnel of C. G. W. Ry.

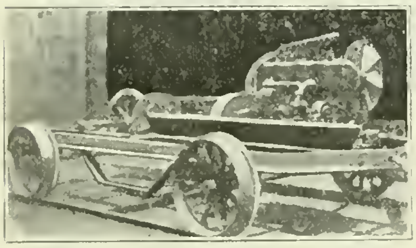
Training Men to Think for Themselves.—One of the most productive labor saving measures in routine bridge and building work is the training of bridge and building forces to think for themselves, and devise methods to get more work done with less labor. This is of such importance that all should be deeply interested, from laborer to supervisory officer. A definite policy by which men who display initiative in suggesting, building and using new equipment, keeping it in repair and adopting new and improved methods of doing work, are shown that their efforts are appreciated, while at the same time a spur is applied to the laggards which will go a long way towards keeping the employes interested in their work and thus increase the output or cut down the expense. A full equipment of good tools is another step in the same direction.

Dumping Concrete in Hopper Car on C. G. W. Ry. Tunnel Job.

Labor Saving Machines on E. J. & E. Ry. Paid for Themselves in 1 Year.—Of the many answers returned to questions on labor saving devices, one which deserves especial mention, came from the Elgin, Joliet & Eastern Ry. This presents the value of the machines in labor saved in a concrete manner. While this is more or less a matter of judgment it is close enough to be of value in deciding whether a machine can be made to pay for itself.

An estimate of the number of days per year which a machine is likely to be used, multiplied by the number of men saved per day, and this product multiplied by the daily wage rate will give a result which should be greater than the interest on the investment, plus depreciation, plus cost of repairs, renewals and incidental running expenses, exclusive of labor. It is interesting to note on the tabulation of the E. J. & E. that the original cost of the machines listed is approximately $90,000 as compared with a saving of $124,160 in labor, assuming the cost of labor at $3.20 per day, and that the saving of the 194 men as shown on the tabulated sheet extended over a period of 200 days per year. The committee is unable to give data on depreciation, repair and operating costs. However, it would appear that such equipment is well worth further consideration from the standpoint of the saving in labor, to say nothing of the ease and speed in handling bridge and building work.

Savings From Use of Motor Cars.—Many figures have been compiled to show the savings resulting from the use of motor cars, but they range from a nominal saving to one beyond good judgment. There is no doubt as to the advantage in the use of motor cars by bridge building gangs. Until recently, the motor cars in use did not have sufficient power and capacity and had too much speed. At present the designs measure more accurately to what is required under actual working conditions, or in other words, instead of a toy we now have a tool. With the exercise of good judgment in the question of speed, the motor car is a valuable asset. Gasoline motor cars are of special value as a labor saving device in transporting men and material quickly; at times they replace a work train and abolish overtime. Varying conditions in different regions make the saving greater in some districts than in others. The proper care and upkeep of a motor is largely a personal equation of operation. The more complicated the construction of the car, the greater the cost of maintenance and upkeep and the less the value of the labor saved. Therefore, to derive the maximum of value from motor cars, they should be simple in construction and of ample capacity, power and reasonable speed. On operating divisions where train service is infrequent the use of motor cars reduces the wear and tear on camp car equipment. A western road estimates the yearly saving per gang to be 1000 work car miles at $.05, or $50.


Motor Car Used on Baltimore & Ohio Southwestern Ry. to Haul Push Cars.

Bridge and building supervisors estimate the saving by the use of motor cars as follows:

I. C. 1 hour per day per man for each gang.

M. C. 35 minutes per day per man for each gang.

C. R. I. & P. 30 minutes to 1 hour per day for each gang.

Penna. 35 minutes per man per day for each gang.

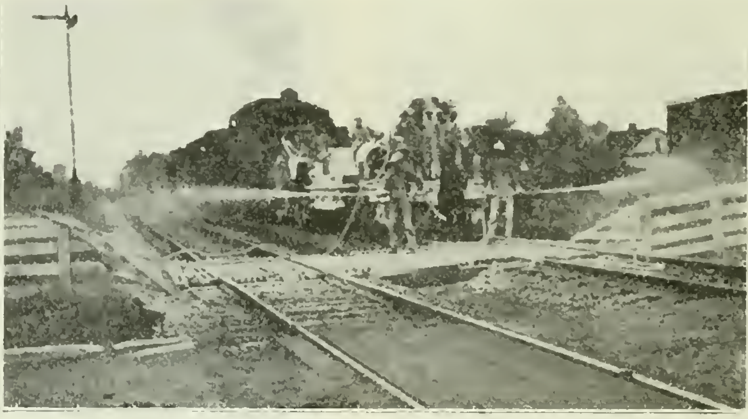
St. L. S. W. $5.00 per day per gang.

N. Y. C. (East). 10 per cent.

M. P. 10 per cent to 20 per cent for the gang per month over the use of a hand car.

Motor cars save the energy expended in propelling a hand car, thus allowing the men to put more effort into their work. They improve the morale of the men by transporting them home for week end visits on lines where the train service is inconvenient and distances reasonable. Emergency work such as a partially burned bridge or small washout can be repaired quickly by transporting both men and materials with motor cars and trailers without the delay of waiting for a work train. A number of roads use the larger sizes of motor cars, carrying about twenty men, to transport employes from the nearest station to the shop terminals, thus saving the daily expense of a train crew and the wear and tear on rolling stock.

Use of Motor Car for Handling Material.—At Trenton, Mo., the C. R. I. & P. Ry. uses a gasoline car for handling local shipments between the material yard and the freight house. This arrangement saves at least one hour per day for four men over using a push car.


Whitewashing Machine in Use on Illinois Central R. R.

The Chicago Great Western Ry. recently replaced the floor in a tunnel ½ mile long with concrete. Motor cars were used exclusively to haul the excavated earth and concrete. The cars used for hauling the excavation were side dump cars of 3 cu. yd. capacity. The car for handling the concrete mortar was a dump bottom car holding 2 cu. yd. The mixer was set on a platform slightly elevated at the tunnel entrance. The concrete was run directly into the hopper car and hauled into the tunnel by a large air cooled motor car. This arrangement worked out to the entire satisfaction of the management and effected a marked saving. The Chicago Great Western Ry. also uses motor cars to pull weed cutters and to haul trailers carrying as many as 40 men or loaded with rails and miscellaneous material. The Baltimore & Ohio R. R. terminal uses motor cars weighing approximately 4,000 lb. and operated on train orders which will handle three special push cars which weigh five tons each when loaded. These cars are equipped with 35 H. P. gasoline engines and friction transmission, giving speed of 40 miles per hour in both directions. They are used to handle all of the materials for the bridge and building department, emergency track work for 31 sections, distribute ties and other track material, move extra gangs, etc. The cars are operated by a crew of two men, an operator and a conductor.

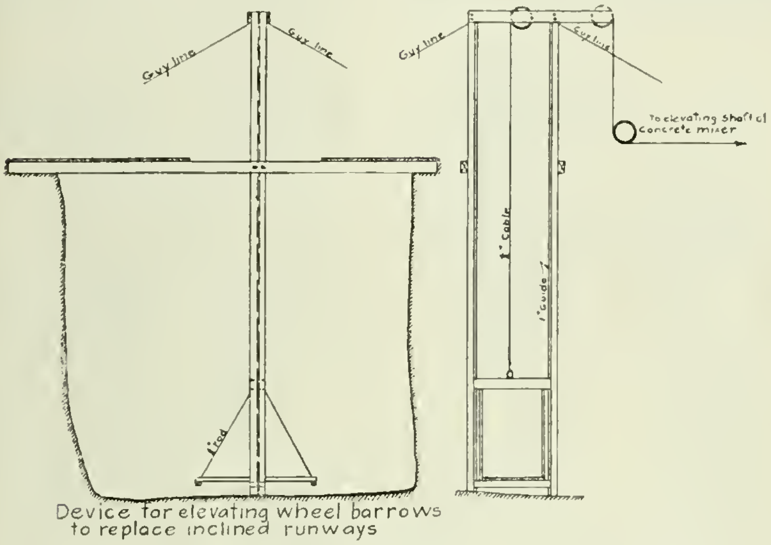
Derrick Crane of Delaware, Lackawanna & Western Railway.

Motors for Boring and Drilling.—More attention should be given to the use of pneumatic and electric motors for boring holes incident to the construction of docks, cribs and protection piers at draw bridges. Electric drills are probably the most convenient and economical to operate where the source of power is close at hand. The Michigan Central Ry. recently constructed a crib at Mackinaw City where all the boring was done by compressed air furnished from a locomotive air pump. The depth of the holes varied from 24 to 34 in. It was found by actual tests of hand boring and power boring that compressed air saved the equivalent of one man working 192 days in the drilling of 3,600 holes. Many railroads have pneumatic tie tampers. These machines can be converted into air compressors which are easily moved and should give very little trouble if properly handled. The Northern Pacific Ry. uses electric motors to good advantage in boring for dowels in timber cribs. Holes ⅞-in. in diameter were drilled through 24-in. timbers in 40 sec.

Dapping Machines.—Only limited data are available regarding the efficiency of the dapping machines. A recent test on the Michigan Central Ry. showed that three men dapped

85 ties in 8 hours, which is about 50 per cent more than the same number of men could have dapped by hand. The New York, New Haven and Hartford R. R. estimates that this class of machinery effects a saving of 50 per cent in labor costs.

A Substitute for the Fire Pail.—Many railroads have had considerable difficulty in keeping pails at water barrels on timber bridges. A bridge and building supervisor devised an inexpensive substitute for the pail by using a small dry goods box with a slat nailed across the top for a handle. The wooden box was submerged about 2 in. below the surface of the water in the barrel and soon became watertight and remained in plain view when wanted for immediate use. Practically no losses of water boxes have been experienced since they have been substituted for pails.


Guy line
Guy line
Guy line
Guy line
To elevating shaft of concrete mixer
1" Cable
1" Guide
Tie rod
Device for elevating wheel barrows to replace inclined runways

Device for Elevating Wheelbarrows.

The Many Uses of a Ditcher.—The name "ditcher" is so suggestive of a single operation that a great many officers pass this machine by when looking for equipment for other types of work, unless their attention happens to be called to the fact that it is adaptable to other needs. At least one make of machine has demonstrated that it is exceedingly useful in places where a crane of one to two tons capacity is needed. It has been used as a pile driver handling piles up to 40 ft. in length, driving an average of thirty per day, as a derrick for dismantling a light through truss, as a construction derrick on a long timber trestle and as a material loader with a clam shell bucket. Where lightness and speed of operation were essential the ditcher was the most economical machine for the job.

Advantages of the Socket Wrench.—The St. Louis Southwestern uses a socket wrench for tightening and removing the nuts of chord bolts, brace bolts and guard timber bolts. A thorough test was made with steel socket wrenches and "S" wrenches in which it was found that socket wrenches effected a saving in labor of 4 ct. per ft. on the complete renewal of a trestle and required 40 per cent less labor to tighten the nuts on the new bolts.

Portable Test Weight for Scales.—To test scales at large freight houses where there are a great number to inspect, the New York, New Haven and Hartford uses a small four wheel truck, which will hold twenty 50-lb. weights. The loaded truck is used as the test weight and is moved to various points in the freight house instead of shifting individual weights.

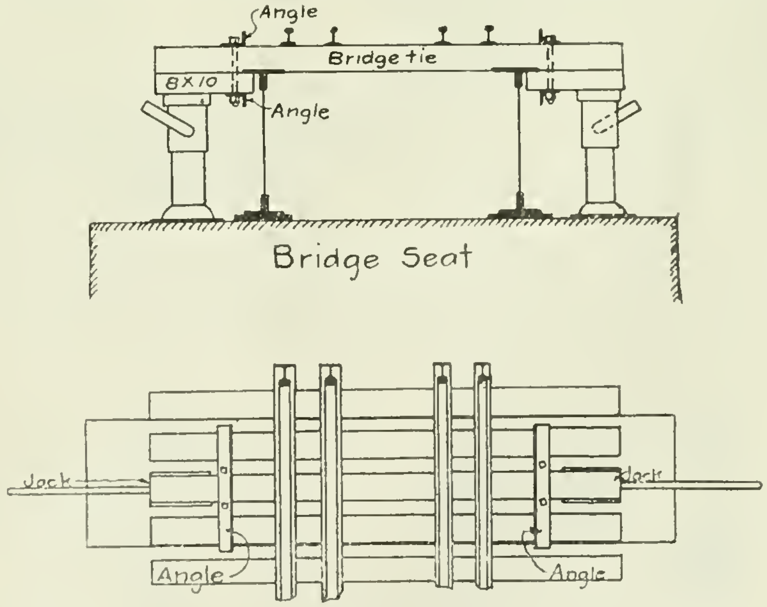
Device for Lifting Wheelbarrows From Excavation Pits.—An inexpensive elevator for hoisting loaded wheelbarrows from excavation pits instead of using inclined runways is used on the Canada Division of the Michigan Central with entire success and effected a nominal saving in labor. The power for operation is furnished by a concrete mixer, the hoisting cable being attached to the mixer elevating shaft.

Air Whitewashing Machine.—An interesting labor saving device is a compressed air whitewashing machine owned and operated by the Illinois Central R. R. for the whitewashing of fences and round houses, and disinfecting stock yards. The operation requires a crew of 8 men. It is claimed that the machine will do the work 50 per cent cheaper than hand labor.

Spike Pulling Device.—A bridge carpenter on the New York Central R. R. constructed a dock spike-pulling device at a very small expense. The base of the track jack, 7 in. by 10 in., is reinforced by a ¾ in. steel plate riveted to it. A rectangular hole 3 in. by 2⅞ in. is cut out in front of the vertical shaft of the base. A loop 11½ in. by 2¾ in. is made of ½ in. by 2½ in. flat steel, the bends being made square. A slot is cut in on the center line from one edge at the bottom ⅞ in. wide and 1¼ in. deep. On the center line of each leg of the loop 1 in. holes are drilled, the first being 4¾ in. from the loop bottom and the next two being drilled on 2½ in. and 2¾ in. centers, respectively. When a dock spike is to be pulled a dap is made in the timber around the spike of sufficient size and depth to allow the loop to engage the spike head, the slot being of sufficient width to pass by the sides of the bolt but not allow the head to pull through. The jack is then set over the loop, a bolt is placed through the holes in the legs over the rack bar and the drift bolt is jacked out. This has proved a very efficient tool and saved considerable labor on dock work.

Test of Paint Spraying Machines.—Paint spraying machines were taken up in former reports of this association. However, it might be of interest to note some recent tests on the Pennsylvania R. R. The East Altoona engine house slant panels in the ventilators were painted by spraying at a cost of $0.029 per yard. If this work had been done by hand it would have cost $0.059 per sq. yd. The grandstand and bleachers at Altoona were spray-painted at a cost of $0.036 per sq. yd.

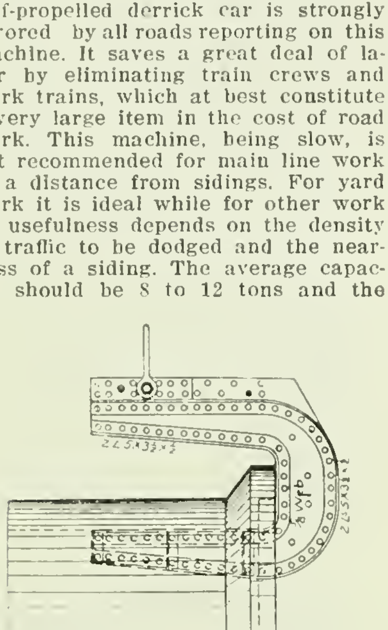
Hook for Handling Pipe.—A structural steel hook can be used for holding the larger sizes of concrete pipe when placed by a derrick. There are two holes in the upper part of the hook so that adjustment can be made as the center of gravity changes for different sizes of pipe. The usual manner of setting pipe is to place a cable or chain sling around the exterior and set the pipe to the desired position. When the sling is removed there is a tendency to uncouple the bell and spigot end. The use of a hook obviates this difficulty and under some conditions expedites the work.



Device for Lifting Girder Spans.

Push Car Derrick.—Bridge and building supervisors on the Missouri Pacific R. R. and the Union Pacific R. R. highly recommend a small stiff legged derrick mounted on a push car, equipped with hand winches and with the necessary clamps for clamping the push car to the track. This is an exceedingly valuable piece of equipment and one which should be placed with all gangs having to take care of pile trestle maintenance.

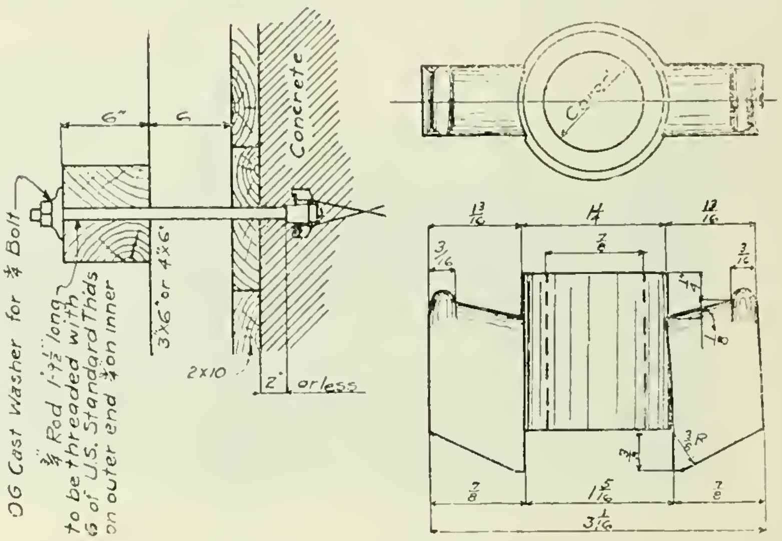
Self-Propelled Derrick Cars.—The self-propelled derrick car is strongly favored by all roads reporting on this machine. It saves a great deal of labor by eliminating train crews and work trains, which at best constitute a very large item in the cost of road work. This machine, being slow, is not recommended for main line work at a distance from sidings. For yard work it is ideal while for other work its usefulness depends on the density of traffic to be dodged and the nearness of a siding. The average capacity should be 8 to 12 tons and the speed from 5 to 15 miles per hour. The greater speed is of advantage.



Steel Hook for Lifting Pipe.

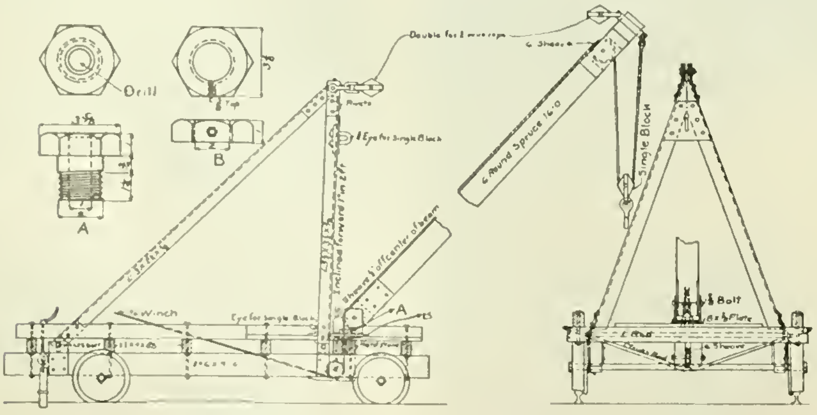
The D. L. & W. R. R. has derricks of its own design, with a capacity of 20 to 25 tons with a speed of 15 miles per hour, and with their numerous attachments are considered the greatest labor saving devices the company ever had.

The self-propelled derrick cars of the Illinois Central R. R. have a capacity of lifting 65 tons and can be operated at speeds varying from 15 miles per hour to 25 miles per hour. Speed is a decided advantage in work on busy tracks, as it dispenses with the use of a work train in many cases. These machines are equipped with 8¼ in. by 10 in. cylinders and 48 in. by 102-150 lb. boilers. Normally the hoist can handle a load of 13,000 lb., while the crank rotates at a speed of 190 r. p. m. The gear ratio, being 1 to 4.67, gives a normal drum shaft speed of 40 r. p. m. The front shaft on the hoist runs at the same speed as the drum shaft. The drum shaft is equipped with a 19-tooth clutch sprocket 20 in. in diameter and is connected by a chain to a 17-tooth split sprocket 18 in. in diameter, clamped and keyed to one of the wheel axles. At 190 r. p. m. of the crank shaft the traveling speed is 4½ miles per hour while the maximum traveling speed would be 12 miles per hour at 500 r. p. m. and the approximate minimum traveling speed would be 2 miles per hour with the crank shaft running at 85 r. p. m.


OG Cast Washer for ¾ Bolt
¾ Rod 1-9½ long to be threaded with 6 of U.S. Standard Thds on outer end ¾ on inner
6"
6
Concrete
3"x6" or 4"x6"
2x10
2" or less
¾" Sq Nut
No 10 Wires U.S.S Standard Gauge
¾ Bolt
END VIEW
VIEW SHOWING POSITION of WIRES

Form Holder for Concrete Construction.

The Illinois Central R. R. also has derrick cars equipped with 27-tooth gears which are put on the extension shaft when more speed is required. With this arrangement a speed of 18 miles per hour can be developed. The standard derrick car is 41 ft. 10 in. long and weighs approximately 60 tons.



Push Car Derrick Used on Boston & Maine R. R.

The water service department of the Pere Marquette uses a 1½ ton chain hoist and tripod made of gas pipe to remove or repair stand pipes. This apparatus is light and may be shipped easily in baggage cars.

Locomotive Cranes.—Locomotive cranes follow very closely the advantages claimed for the self-propelled derrick. Their scope is, however, broader and the average work which can be handled runs from 15 to 30 tons. The wrecking cranes are usually made use of where exceptionally heavy loads have to be handled. The value of the locomotive crane lies in its adaptability to many uses. With a clam shell bucket it may be used for handling rubbish, coal or other materials or for excavation. For loading or unloading cars of gravel, cinders, coal and doing quick excavation, it is unequaled. Equipped with pile driver leads and a steam hammer the machine can do all of the work of the average pile driving outfit and with air compressor and air tools it can handle sizable timber framing jobs at a considerable saving. One road estimated that its 20-ton locomotive crane speeded up the work to the extent that it paid for itself every 4½ months.

Pile drivers especially equipped as such are used where much work is to be done but with the readily converted locomotive cranes and derricks they are not always a necessity. It is found that the combination equipment fits the average work better.

For loading and unloading material out on the road locomotive cranes or self propelled derricks are recommended by all for heavy work. For yard work, stiff legged derricks, carefully placed and operated electrically, are favored although special self propelled derricks are frequently used. Several roads have systems of distribution which eliminate the rehandling of material at yards. Steam, electricity and compressed air are the chief sources of power as reported. Where a road engine is necessary to handle a derrick or pile driver, it has been found economical to pipe the steam from the locomotive, thus saving an additional fireman and the expense of running a separate boiler.

Concrete Forms.—Portable concrete forms of either steel or wood are not in general use. Their economy is not great as the large variations in conditions to be met do not allow many standard sizes of forms. Their usefulness depends entirely on the amount of work of standard shape, such as lining tunnels, building long walls, arches, etc. It has been suggested that a standard size culvert might be designed which could cover many cases where at present there is a variation of size due largely to a matter of judgment on the part of the designer. The saving in forms for this, however, might easily be offset by the cost of additional concrete where the standard culvert was larger than necessary. It would be poor economy to build a culvert smaller than necessary in order to fit an average size for the road. Where it is possible to use steel forms the work undoubtedly goes ahead faster.

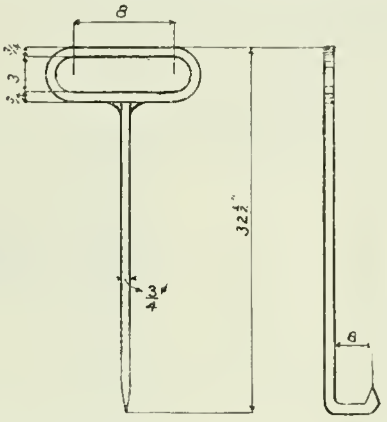
Portable Circular Saws.—Portable Circular Saws are good labor savers where sufficient work of one kind is to be done. For form work it is claimed that they save as high as 25 per cent of the cost. Only about a third of the roads reported having these machines, but all favored their use. It has been suggested that these saws could be used to cut old bridge timbers into smaller sizes and thus reclaim considerable old material.

Cutting and Welding Outfits.—Acetylene cutting and welding outfits for bridge gangs have been reported as almost indispensable for those roads having to remove or repair old structures. They may be used for cutting up or repairing girders in the field or dismantling old trusses which must be taken out of the way quickly. They may also be used for cutting I-beams, plates and angles in the field where a close fit is not required. They have been used to advantage in cutting off 1 in. round drifts when trestle caps were to be replaced quickly under traffic. On the whole, they are a very useful addition to a bridge gang outfit. The Boston & Maine R. R. estimates that repairs to a steel bridge can be made 50 per cent cheaper with this device than by the use of ordinary air cutting tools, especially if some of the parts in question are inaccessible to rivet busters.

Portable Telephones. — Portable telephones have proven very efficient for bridge jobs at a distance from a station and where it is necessary to get advice from the dispatcher as to time that track can best be out of service. They do not relieve the foreman of any precaution against accident but help to keep the work running smoothly. They are a safety device, keeping the foreman posted on the location of trains and thus enabling him to travel by motor car with greater safety. Phones are a necessity on anything but the smallest jobs.

Tool Grinders.—Tool grinders, using various sizes and grades of carborundum wheels, have practically displaced the grindstone on most roads. They are indispensable around a shop and a great time saver in the field. Being small, these tools are easily carried to the job and can be fastened to the frame of the motor car or push car and grind the tools as soon as they need it, performing the work quicker than the old fashioned grindstone. Several foremen have provided themselves with ¼ in. carborundum wheels which they use for gumming out crosscut saws. In this way they can easily keep their saws in shape themselves.

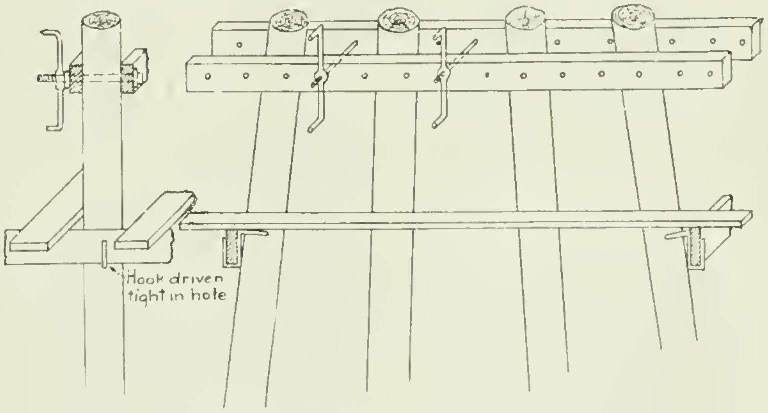
Tinners' and slaters' tools are furnished only on those roads having a large number of building roofs to keep in repair. It is recommended that a full set be kept at division headquarters to be sent wherever needed.



Chord Hook for Removing Stringers.

Chain Hoists.—Chain Hoists are most useful around machinery and may be used to great advantage on draw bridges, pumps and boiler repairs. They are a great aid in removing heavy gears on draw bridges which happen to be in confined spaces.

Portable Forges. — Each gang should have a portable forge as most bridgemen can do the ordinary blacksmith work that is necessary, such as sharpening picks or bars, putting in a chain link and welding bolts, etc. Much time and annoyance are avoided by doing this work on the job rather than sending it to the shop.



Device for Holding Scaffold Plank and Lining Piles.

Tongs for Timber Handling.—Besides the ordinary "ice tong" type for handling timber with a derrick, crane or ditcher machine, one road reports the conversion of hand carrying tongs. The handles are removed from two pairs and a chain about 6 ft. long is passed through the place where the handles were. Both pairs are then hooked into the timber and it is found that less care is needed to center the hooks as they tend to equalize the load. It is suggested that specially designed double tongs of this type would be better than the single pair ordinarily used.

Pulling Machine.—A very useful pulling machine has been employed by the Long Island and is recommended by that road for tying up pile clusters at ferry and transfer docks, lining and stay-lashing piles and the like. It is a small portable hand-operated affair which can be carried by two men and exerts a pulling power equal to a small steam hoisting engine.

Compressor Outfit.—Of the lighter portable compressors those used for the tampers seem to meet with the approval of several roads for adaptability to small bridge repairs up to 400 or 500 rivets and are reported to save 10 to 15 per cent over hand labor alone. For heavier work the 9½ in. pump and cross-compound pump with three standard reservoirs was found to be a good combination where placed as accessories on the pile driver. This outfit, working at 130 lb. air pressure and using one wood boring machine and one air drill, drilled for and drove 3,500 screw spikes in 10 hrs. with a force of three men. It should be possible to do something like this on timber framing, especially on a fair sized trestle job. Air tools have been used for boring, grinding and drilling and for reaming, riveting and concrete drilling, all proving great labor savers.

Electrically Operated Tools.—Electrically operated tools are of great value where power is available. They have about the same range of use as air tools with perhaps a greater advantage where large power is needed. Electric welders are very useful and particularly economical in welding broken castings on pile drivers, derricks, draw bridges and bridge pedestals. This device not only saves time in getting damaged equipment back in service but also reclaims considerable material that would otherwise be scrapped. The Michigan Central R. R. recently welded a broken bridge pedestal with electricity successfully at an expense of about $100, which otherwise would have been scrapped and replaced at an expense of approximately $1,800. Electric welding machines have a limited use in bridge and building work, but such work as may be required can usually be performed at the locomotive shops.

Ball Bearing Screw Jacks.—A large percentage of the roads have discontinued the use of hydraulic jacks for bridge and building gangs and replaced them with the ball bearing screw type. Unless the hydraulic jacks are kept in good repair the valves leak, causing unsatisfactory results. Screw jacks having capacities ranging from 10 to 25 tons will handle a large portion of the routine bridge work and should be furnished for every gang. Screw jacks and pulling jacks are economical tools and ought to be supplied as a part of the equipment for timber and steel gangs. It is the opinion of the committee that high duty jacks for lifting turntables, steel truss bridges, etc., should not be supplied the various gangs, but should be kept at division headquarters.

Rail Clamps.—Rail Clamps for excavation have been used with success on the Elgin, Joliet & Eastern R. R. and under certain conditions save considerable labor. This is particularly true in supporting tracks over trenches when the earth is frozen. Trenches should be thoroughly braced with timber to prevent the excavation from becoming excessive in width, thus causing an excessive width of unsupported span.

Trench Pumps.—Where the volume of water is such that it can be handled by gasoline trench pumps, this class of equipment will not only save the expense of two or three men but also the expense of the original investment in a comparatively short period. Gasoline trench pumps are particularly adapted for sewer work, water works gangs, foundation work and mason gangs.

Track Dollies.—Two wheel track dollies are used on most of the roads. This device is particularly adapted to transporting caps and stringers where partial units of a trestle are repaired. Under certain conditions it is estimated that the use of track dollies will save from one to two men as compared to handling similar work with a push car.

Device for Lining Piles.—An efficient device for lining piles and holding scaffold plank consists of two pieces of timber with holes about 12 in. apart placed on opposite sides of the pile bent near the top and pulled together by means of bolts placed through opposite holes of both timbers. A "U" shaped rod, tapped in the center, is used as a nut and acts as a lever. The scaffold hook consists of pieces of iron bent in the form of a rectangular hook with one leg driven into the pile, the width of the hook being about the same as the scaffold plank. This device has the advantage of holding the scaffold rigid and prevents the longitudinal plank from turning from the edge to the flat side, which frequently occurs where they are held by ropes of chains suspended from the deck.

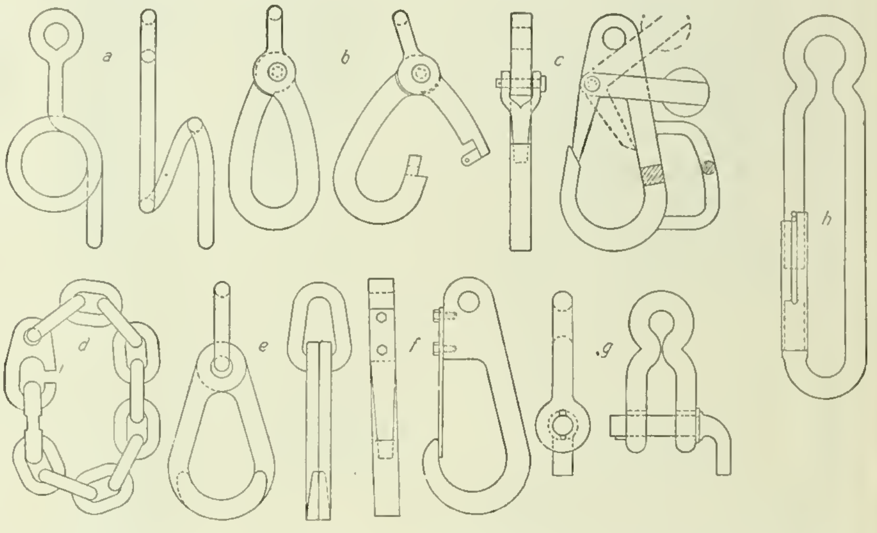
The Individual Man and Gang.—The most important field for improvement and cultivation are the individual man and gang to get them to think for themselves, to suggest methods of increased efficiency and to instill a feeling of loyalty to their employers, as without these, any mechanical device is doomed to failure. Men should feel that their best interests are served by giving their employers efficient service and only as their employers succeed, can they share in their success. A healthy rivalry should exist among the different gangs with a notice of any particular job that was well done. The facts regarding such a job should be sent to the other gangs.

The Use of Technical Magazines.—The Michigan Central R. R. furnishes its bridge gangs with technical magazines, one copy to each gang. The men in most cases have shown considerable interest in these publications and spend their spare time in discussing different methods of handling the work instead of discussing topics which have a tendency to cause trouble and undermine the morale of the organization.

Safety Hooks for Shaft Sinking Buckets

In shaft sinking the buckets are usually hooked to the rope, since the rope must be disconnected from a bucket each time it is landed. Although the ordinary open hook should not be permitted, nevertheless its use is altogether too common.

Seven types of safety hooks and one safety clevis are shown in the accompanying illustration, which is reproduced for a bulletin "Safe Mechanical Equipment for Use in Shaft Sinking" issued recently by the U. S. Bureau of Mines.



Safety Hooks and Clevis for Shaft Sinking Buckets: (a) Pigtail Hook; (b) Foundation to Safety Hook; (c) Hook With Weighted Latch; (d) Chain Hook; (e) Sister Hook; (f) Hook With Spring Latch; (g) Safety Clevis; (h) Hook With Sleeve Latch.

The simplest one to make is the pigtail hook, a type successfully used in the Joplin zinc district where hoisting with buckets in vertical shafts is common. The pigtail hook is easily manipulated, but should the rope be slackened so that the position of the hook is inverted, it may become detached as the rope is drawn taut again.

The sister hooks are simple and efficient, but both hands are needed to adjust them, which is often inconvenient.

The hook with a weighted latch, with a safety handle to prevent injuring the hand, may be used with one hand. It is almost impossible for such a hook to be disengaged unintentionally. There is, however, some likelihood of the latch being rendered inoperative by becoming bent or clogged with dirt.

The hook with a spring latch is used in many mining districts. The body is made of wrought iron or steel and the spring latch of tempered steel. This spring is the possible weak feature, since it may break or become bent back if it is not properly made and tempered and may not resume its normal position when released, in either case failing to close the throat of the hook.

The chain hook which, with its chain, is passed through a ring on the rope and the bail of the bucket requires somewhat longer to engage and disengage, but unless the hook is opened by overstraining there is little likelihood of its coming loose. The Foundation Co. safety hook is practically positive in its action unless the hook becomes so strained that the tongue of the latch will not enter the slot in the hook, when it becomes useless.

The pin of safety clevis must be turned half around, until the handle is pointed up, before it may be withdrawn to detach the bucket, making the chance of unintentional disengaging very remote, but the pin and the lug may become so battered by the rough treatment the clevis receives that it can be manipulated only with difficulty.

The sleeve latch is a piece of pipe slipped on the hook before it is entirely formed; this closes the hook when pushed down over the opening to the position shown. If the pipe sleeve is so turned that the pins are not in line with the slot it is impossible for the sleeve to slip up and bare the opening. The sleeve is, however, likely to become battered or clogged with dirt and grit, and thus fail to slip down properly.

An Excavation Kink

An ingenius method was employed in excavating for the pit for the Upland Roads sewage pumping station of Newton, Mass. The pit was constructed for nearly all of its depth through water bearing clay overlaying a strata of water bearing gravel. The excavation of the pit was facilitated by the driving of four 2½-in. tubular wells through the clay into the water bearing gravel and reducing the ground water table by pumping the water from the gravel through these wells and discharging it into a nearby ditch.

Agricultural Engineers to Meet at St. Louis.—The 16th annual meeting of the American Society of Agricultural Engineers will be held Dec. 27, 28 and 29 at the Planters Hotel, St. Louis, Mo. Raymond Olney, St. Joseph, Mich., is secretary of the society.

Car Track Zone Paved with Precast Concrete Slabs

During the spring of 1921, the Salt Lake & Utah Ry. awarded to the Intermountain Concrete Co. of Ogden, a contract for the manufacture of 2,500 pre-cast concrete slabs for paving the single track car zone through the main street of Spanish Fork, Utah. The Salt Lake & Utah Ry. is an interurban road running southward from Salt Lake City, a distance of approximately 70 miles. In addition to operating regular interurban passenger cars, weighing about 30 tons each, the company operates freight trains hauled by electric locomotives weighing from 40 to 50 tons. The improvement is described by Quince Rice of the Intermountain Concrete Co. in the July issue of Concrete Highway Magazine.

Car Track Zone in Spanish Fork Paved with Precast Concrete Slabs.

The paving is composed of four lines of slabs, two between the rails and one on each side in the space between the rails and the street pavement. The slabs inside the rails are 25½ in. wide by 5 ft. 2 in. long. Those outside the rails are 22¼ in. wide by 5 ft. 2 in. long. All slabs are 4 in. thick, reinforced with A. S. & W. Co.'s No. 107 triangular mesh reinforcement. The track zone occupies a space 9 ft. wide, the remaining portion of the street having previously been paved with 7-in. concrete.

The slabs were fabricated on an especially prepared concrete platform in Salt Lake City. The forms were made of 2 by 4-in. timbers, braced at sufficient intervals to firmly hold the concrete in place. They were assembled in sets, each set holding 6 slabs. These forms were laid on the concrete floor, which had first been covered with newspapers to aid in retaining moisture.

Concrete was transported from the mixer to the forms in wheelbarrows. After being placed in the forms, the concrete was well tamped and spaded, particularly around the edges, struck off with a straight edge and rolled with a light metal roller until no more water appeared on the surface. The exposed surface was finished with wooden hand float. As soon as the slabs had received their final finish they were covered with wet burlap until they had hardened sufficiently to permit sprinkling. A stream of water played over them day and night for a period of 10 days. Following the sprinkling period the slabs remained on the platform for 48 hours, after which they were taken to a stock pile and set on edge. This was done with a low-lying, rubber-tired truck, such as is commonly used in transporting concrete products like pipes and silo staves.

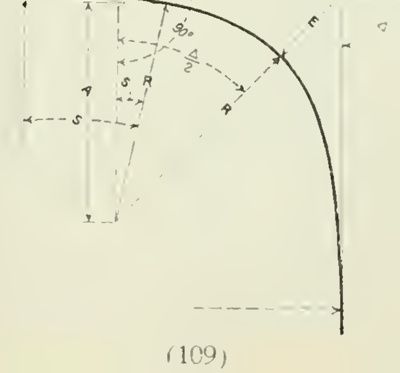
Precautions were taken to use only the cleanest aggregate. The sand was supplied from the Ideal pit near Sandy and contained less than one-half of 1 per cent of silt. Coarse aggregate ranged in size from ¼ in. to ½ in. and was uniformly graded and washed. Various mixtures were used, being designed according to Professor Abrams' Table of Proportions and varied with the grading of the aggregates. The cement factor was kept constant at 1.65 bbl. per cubic yard. Mixes varied from 1:2:3 to 1:3:2. An average of 6 gal. of water per sack of cement was used in mixing the concrete, which produced a mix just wet enough to make it workable. Tests were made of the aggregate and mixes at least once daily and every precaution was taken to obtain the best quality of concrete.

About 30 days after making the slabs they were placed on board flat cars with the aid of a hand derrick and transported to Spanish Fork City, where they were unloaded by hand at convenient intervals along the track. A layer of clean sand about ¾ in. deep, was spread over the ties and carefully screened to form a base for the slabs. The slabs were easily handled by four men using large ice tongs.

Solution for Compound-Curve Trackwork Problem

A simple method for finding the tangents and externals of symmetrical curves in special track work using available tables, is given by Mr. L. R. Brown, office and field engineer, New York State Railways, in a recent issue of the Electric Railway Journal. His article follows:

Since the advent of the standard spiral or switch easement, the most frequent problem encountered in the designing of special track work curves is the computation of the tangent distances and externals of curves where a standard spiral is used at either end of a given center radius. There are tables given by the steel companies which give the X, Y, S of each of their standard spirals. There is also a booklet put out by one company which gives tables showing these dimensions for the A. E. R. A. recommended spirals. Thus in nearly every case these dimensions as well as the center radius and total angle are known.



The problem, then, is to solve the tangent distances and externals. This problem, of course, is easily solved by trigonometry and there are several methods of doing it. Much time is wasted in the drafting room in computing these problems unless a given method already worked out and checked is used. If a copy of the formula is at hand it is only necessary to substitute in the formula. It likewise saves time in checking the computations.

The simplest method found by the writer for solving the above problem is that given by the following formula. This method can be used only where the same spiral is used on each end of the curve.

Given: X, Y, S of any spiral, R, the center radius, and △ (see figure).

Find: T and E.

$$A = R \cos S$$

$$B = R \sin S$$

$$C = (A + X) \tan \frac{\Delta}{2}$$

$$E = \frac{A + X}{\cos \frac{\Delta}{2}} - R$$

$$T = C + Y - B$$

Japan Company Orders Largest Winding Transformers Ever Made.—The largest three winding transformers yet built, which are also the largest transformers ever supplied to Japan and the largest single phase transformers for operation at a voltage higher than 132 kv., were recently ordered by the Tokyo Electric Light Co. The new equipment, consisting of four 21,000 kv-a., single phase transformers, which are in course of construction in the East Pittsburgh works of the Westinghouse Electric & Manufacturing Co., will be utilized in connection with the development of power on the Tone River to supplement the power being developed on the Shinano and Makatsu rivers, to be transmitted to Tokyo at 154 kv. The Tokyo Electric Light Co. already has a very large system operating at 66 kv. and the transformers, which will be installed at Komatsu, will be used for tying together the 66 kv. and the 154 kv. systems.

Accidents on Street Railways.—According to the national safety council, street railway transportation in the largest cities of the United States has come to rank with the safest forms of traffic. In 1915, the council report states, the number of people who lost their lives by street car accidents in 35 American cities with a population of 17,500,000, was 559; in 1916, 668; 1917, 785; 1918, 787; 1919, 576, and 1920, 525. The sudden drop in the last two years is credited to safety education and development of traffic control.

Winter School for Electric Railway Track Men

How the Eastern Massachusetts Street Ry. Co. Familiarized Its Supervisory Forces with the Latest Methods of Doing Track Work

A school for all its track forces, with the purpose of further training roadmasters, foremen, welders, bonders, grinders, switch repairmen and others of the supervisory force was conducted the past winter by the Maintenance of Way Department of the Eastern Massachusetts Street Railway Company under the direction of Mr. F. B. Walker, Chief Engineer. How this school was conducted was described by Mr. Walker in AERA, from which the matter following is taken.

It was realized that methods of doing track work, particularly the construction of new tracks, rehabilitation of old tracks, welding, grinding and proper treatment of joints, tie renewals, drainage, special work maintenance and many other subjects had very rapidly advanced during the past few years and that, although the employes of the department had, theretofore, received some training, it was necessary to instruct these men further in the various kinds of work, and the winter seemed the best time to conduct this further training, or as it was termed, the Winter Track Department School.

Dividing the Work.—Considerable study was given to the best methods of carrying out this work and subjects were assigned as follows:

Return Circuit Engineer Warring, Bonding and Joint Welding.

Division Engineer Smith, Surface Welding and Grinding.

Division Engineer D'Arcy, Special Work.

Division Engineer Waller, Drainage in Open Track.

Division Engineer Hyde, Tie Renewals and Joint Repair Work.

Division Engineer Packard, Construction of City Tracks.

Chief Clerk Mahoney, Reports.

Organizing the School.—The method of conducting the school, was about as follows:

A suitable classroom was equipped to accommodate about twenty-five. It could be darkened and a projecting lantern and silver-faced screen were furnished so that slides could be used to illustrate the talks. School was in session five days in the week, from 10 until 12:30 and from 1:30 until 4, beginning late in December and running through to the latter part of February. The morning session was used entirely for illustrated lectures, after which the men were dismissed for lunch and then returned to a shop in which had been set up the particular class of track department tools or machinery which had been the subject of the lecture in the morning.

When the lecture on welding and bonding was given, the shop had installed in it five or six different welding and bonding machines, connected up and ready for operation and the engineer was assisted in the shop work by welding instructors. And likewise, when the morning talk was on surface welding and grinding, the various pieces of apparatus which had been used for joint welding were taken out and these replaced by the resistance type of surface welders and various types of grinding machines.

Equipment Used.—The list of apparatus used in the shop work consisted in general of the following:

Rail Welding Bonding Co. dynamotors, type W and type B; G. E. Co. motor generator welders, Westinghouse Co. motor generator welder, Erico resistance welder, Indianapolis resistance welder, Universal grinder, Seymour grinder, old and new type, Reciprocating grinder, Ingersoll-Rand pneumatic air tampers, Jackson electric air tampers.

The shop also contained sections of both sand and rock ballasted track so that seam welding, surface welding, grinding, tamping and other operations could be carried out on actual full sized track sections.

Arranging the Classes.—About 125 men were put through the school. These were arranged to come in sections of 15 to 20 so that there could be considerable individual work and time for discussion, and so that neither the classroom nor the shop would be overcrowded during the work. They were further divided so that roadmasters and engineers came in one section, and there being about 60 foremen, they were divided into three sections; welders in another section; grinders in another, and so on. The subject was assigned for each week; the work preceeded throughout the entire course so that all the roadmasters and engineers had the lecture and shop work at the beginning of the week, followed by a group of about 20 foremen each day for the middle of the week and later, the others in groups to complete the week so that each subject was given to the entire forces before second subject was taken up. This meant that each individual did not have to appear at the school more than one day a week.

At the opening sessions of each group at the beginning of the school term, Chief Engineer Walker briefly addressed the men as to the purposes of the school, as it was found, when the school work was announced to the various members of the track department, that there was considerable misapprehension as to just what was to be taught. A great many of the men felt that it was the purpose to teach them how to drive a spike or how to handle a shovel, in other words, to do the minor, normal operations of working on the track, so that it became quite necessary to sell the idea of the school to all the men before really attempting to carry on the school work.

Men Became Enthusiastic.—After all of the men had gone through one session, particularly after they had heard the lecture and seen the demonstrations of joint welding and bonding and discovered they had seen this process carried out for a year or more, found that they knew very little about what the department was trying to get at and the reasons therefor, what had been accomplished and what was hoped to accomplish—the school idea was thoroughly sold. All concerned were very enthusiastic over the idea and went into the work with greater enthusiasm and desire to learn than had been anticipated in the most optimistic moments.

The school has been most successful, not only because it was possible to show all of the men who would be in charge of the work just what it was necessary to accomplish, but the department was able to receive from these men very valuable suggestions as to particular methods of carrying out the work. These suggestions were expected from the engineers and roadmasters, but some of the best suggestions were from those least expected to be heard from.

Informality and Comfort — The classroom work and shop work was carried out in the most informal manner. The men were told to be at ease but they must pay attention to what was being said. They could leave their hats on; they could smoke; they could move around; they were expected to ask questions, in fact, some of the sessions developed into free-for-all discussions and arguments which were usually brought to a close after a reasonable time by the engineer in charge of the lecture, when he saw that time was being wasted in useless discussions, but the engineer-lecturers were instructed to and were keenly anxious to bring out discussions of difficult or little understood points.

The groups of men were told that the company had carried out a large program of rehabilitating its tracks; that an enormous amount of good work had been done, but that more work and better work was expected; that two things were essential, good results and lower costs; that the department expected all the men to be satisfied with nothing less than the best, and on the other hand, all men were expected to get nothing less than the best at the lowest expense; that they would be shown the cost of doing work as far as possible; that the department wanted everybody to know the costs; that there was nothing secret about costs nor was there any secret about the various processes of doing the work; that they should know how to get them at the lowest possible expense; that the foremen would receive from the roadmasters all information which they could possibly give as to methods of doing work and also such information as they had as to cost of doing work; that they were expected to keep track of the costs each day for each item; that information of this kind was of little value if buried in the records of the accounting department; that the department expected not only the roadmasters and foremen but also the individual operator of the machinery to know more or less of his results and more or less of the cost of producing the results.

Cost to Company Small.—Approximately 400 slides of photographs and diagrams were used to illustrate the points brought out by the engineer lecturer. To cover the cost of slides, lantern, fitting up the office, moving of machinery, but not including the time or expense of the men coming to and from the school, there was appropriated $500.

During the progress of the school, many street railway men and others attended.

Mexican Railway to Be Electrified.—All the mountainous part of the Mexican Railway, more than half the road, between Mexico City and Vera Cruz is to be electrified, according to a press dispatch from Mexico City. The work is to begin at once under direction of the General Electric Company of New York. The line is to be double tracked.

Comparative Test of Manganese Steel and Carbon Steel Dredge Cutter Blades

Some interesting data on the comparative economy and efficiency of carbon steel and manganese steel cutter blades used in the U. S. Engineers Department dredge, Captain Huston, in San Jose Harbor, Porto Rico, are given in the current issue of The Military Engineer, the information being based on a report from the District Engineer of the Porto Rico district.

The material encountered in the dredging of San Juan harbor is classified as follows: Mud, 30 per cent; coral and sand, 20 per cent; very stiff clay, 50 per cent. All three classes are often found in the same cut. In mud the resistance and wear on the cutter blades is practically negligible, coral and sand offer medium resistance but cause a very high rate of wear, and stiff clay offers exceedingly high resistance but moderate wear. In dredging mud, coral and sand the resistance being low, worn or dull cutter blades may be used without reducing the efficiency of the dredge materially; but in clay such as that encountered in San Juan harbor the blades must have a cutting edge for efficient operation.

The cutter blades of the Captain Huston that were supplied with the dredge when purchased were made of carbon steel. The dredging work in San Juan harbor with the Captain Huston was commenced on August 18, 1920. The old carbon steel cutter blades that were attached to the spider when the dredging was commenced wore out and were replaced with new carbon steel blades on Nov. 2, 1920. Between this latter date and April 26, 1921, three sets of carbon steel blades were worn out. The total pumping time was 1,581 hours. The cost of these blades, as determined by the cost of six purchased by this office in November, 1920, and the value of the eleven listed as spare parts furnished with the dredge, which were valued practically the same as those purchased in 1920, was $1,225.95. On account of the rapid wear of the carbon steel blades, it was decided early in January, 1921, to substitute manganese steel blades for carbon steel blades. Twelve of these blades were purchased at a cost of $1,226.45 and placed in service April 28, 1921, and the twelve were worn out on February 5, 1922. The total pumping time was 3,120 hours. The record of the two classes of steel blades is given in Table I.

The unit first cost of manganese steel blades is about 20 per cent higher than that of the carbon steel blades, but the pumping time in hours per blade shows that the manganese blade will last 275 per cent longer than the carbon blade and the cost of manganese blade is shown to be less than 50 per cent of the cost of the carbon blade on account of the increased serviceability. Twenty-four hours are required to remove old blades and attach new ones. In making the change about 75 lb. of babbitt metal is used at 50 ct. a pound and the cost of changing a set of blades, taking into account the lost time of the dredge, is approximately equal to the purchase price of a set of blades, so that it is evident that each set of manganese blades purchased practically pays for itself and there is, therefore, no question as to the economy in using them.

TABLE 1.

	Carbon steel.	Manganese steel.
Number of blades	15	12
Actual cost	$1,225.95	$1,226.45
Unit cost	$81.73	$102.20
Time in service	11/2/20 to 4/26/21	4/28/21 to 2/5/22
Total pumping time, hours	1,581	3,120
Pumping time for each blade, hours	105.4	290
Cost per blade per hour	$0.775	$0.354
Material dredged:		
Mud, cu yd	118,420	181,220
Clay, cu. yd.	202,460	299,710
Sand and coral, cu. yd.	61,121	216,070
Total cu. yd	382,000	697,000
Unit blade cost per cu. yd. coral and sand dredged	.00134 ct.	.00047 ct.

Highway and Railway Transportation of Goods

How Motor Trucks Can Cooperate with the Railroads Outlined in Address October 28 Before Washington Conference on Education for Highway Engineering and Transport

By W. H. LYFORD,

Vice President, Chicago & Eastern Illinois Ry.

Transportation is not complete until the goods are moved all the way from the premises of the shipper to the premises of the consignee and, for brevity, we will call such movement "complete transportation." Also for brevity, we will use the British term "trader," which includes both shipper and consignee, or all persons for whom transportation of goods is furnished for hire.

The trader is concerned only with complete transportation. His greatest need is that complete transportation shall be furnished with regularity and within reasonable time. His secondary need is that the charges which he must pay for complete transportation shall not be more than the traffic will bear, without curtailing his profitable trade.

Complete transportation cannot be furnished regularly and promptly unless the charges of the carrier are high enough to pay all the expenses of carriage and a profit sufficient to warrant the investment of capital and energy in the installation of the transportation service and in increasing the service as traffic increases. In normal times the volume of freight traffic in this country increases at a rate of not less than 6 per cent per year.

The trader is entitled to the best transportation service which can be furnished for the charges which he pays and it is the duty of carriers who, singly or jointly, undertake to furnish complete transportation, to make their charges as low as is consistent with the maintenance of adequate, regular and prompt service.

Four Classes of Transportation.—We are accustomed to think of the transportation of goods as divided into four general classes: parcel post, express, less-than-carload or package freight (commonly called l. c. l.) and carload freight.

The essential difference between carload and l. c. l. freight is that carload freight is loaded and unloaded on an industry track or a team-track by the trader, or by someone employed by him, while l. c. l. freight is loaded and unloaded and passed through a station at the expense of the railway. Consequently, carload rates are substantially less per ton than l. c. l. rates for carrying the same goods.

Collection and Delivery.—Whether the government, the express company or the railroad company undertakes to transport the goods, the railway actually performs the entire transportation service, except the movement between the premises of the traders and the stations of the railway companies. Such movement is called "collection and delivery." Parcel post is not collected, but it is delivered by the government. Express is collected and delivered by the express company. Freight is collected and delivered, not by the railway company, but by the trader or by the owner of trucks or teams, whom we call "the trucker."

Because the railway does not furnish collection and delivery and that service must be performed by or at the expense of the trader, the traders have located their industries as close as possible to railway stations. Consequently, the vicinity of the freight station is usually a congested district in any large city. If the railway furnished collection and delivery, the location of the freight stations would be immaterial to the trader. A distance of two miles between the locations of two stations in a large city may make a difference of 300 per cent in the interest charges on the real estate occupied by the stations. In Chicago the interest charge alone on real estate at 12th St. on which a freight station is located is more than $2.30 per ton of freight handled through the station. If the station were located at 33rd St., such interest charge would be reduced to about 80 ct. per ton. The amount of interest saved by moving the station to 33rd St. would pay the cost of well organized cartage between the 33rd St. station and the premises of the trader. The present cartage charges would be saved.

Outbound freight is moved to the station in whatever way and at whatever time the trader chooses, during the business day. Inbound freight is removed from the railway station in whatever way the trader chooses and, on the average, about three days after the freight arrives. Therefore, the station becomes a storage warehouse, congested with piled-up freight awaiting delivery to the trader, at his convenience. With collection and delivery service controlled by or in full cooperation with the railway, large freight stations with storage facilities would be unnecessary. A narrow platform, with a roof over it and with tracks on one side and a highway on the other is all that would be required.

With very few exceptions, railway freight stations in large cities already are so congested that, unless we can find some way to pass more traffic through the existing facilities, or to keep on enlarging and multiplying them, by extravagant expenditures for additional real estate and track connections, the railways will not be able to handle the normal increase in freight traffic.

Railway companies are organized to furnish transportation. Storage is a separate field for enterprise. The public warehouse is needed and should be fostered because it can be operated at a profit. Storage in railway stations rarely is profitable to the railway company and it seriously interferes with the legitimate function of the railway—to furnish transportation.

The fields within which complete transportation of goods can be furnished by highway alone or by railway alone are limited.

There are very few industries or residences in continental United States which are not connected with each other by highway and it is physically possible to perform complete transportation of goods by highway between almost any two industries or residences. But such transportation is most economical only when limited to the movement of goods between homes or industries which are within reasonable trucking distance from each other. The determination of such reasonable distance depends on many conditions and a competent truck expert will place it anywhere between 25 and 150 miles. Of course there are emergencies and peculiar industrial conditions which, in rare cases, make trucking economical over a distance of several hundred miles, but such cases are negligible in the consideration of the whole field of highway transportation.

On the other hand, comparatively few industries and practically no residences are connected with each other by railway. Therefore the field for complete transportation of goods by railway is restricted to the movement of carload freight between those industries which have direct rail connections. In that limited field the railway is the most economical means of transportation. A fair example is the movement of coal from mine to an industry located on a side track.

Competition.—In this country four different agencies are competing with each other for the transportation of the same goods: Parcel post, the express company, the railway and the trucker. While the parcel post and express are transported over railways, the government and the express company compete with each other and with the railway for the carriage of packages weighing 70 lb. or less, and the trucker competes with the three other agencies.

Competition for the local carriage of goods within city and suburban areas ought to be welcomed by the railways, as they perform this service at an actual loss, while the trucker can perform it at a profit. On the other hand, competition with the railway for the carriage of goods through rural districts, along main lines of railway, is harmful to the railway and unprofitable to the trucker.

Co-operation.—For parcel post there is complete co-operation between railway and highway transportation, as the government has its own cartage system. There is like co-operation in the express business, as the express company operates its own trucks and wagons. For freight traffic there is hardly any co-operation between the railway and the motor truck.

I have marshalled the foregoing facts without any idea that they would be new to you but that they might form a background for the statement: That unless there is a radical change from present practices in railway transportation in the United States, our great transportation system, which is the wonder of the world, will become a hindrance to the further progressive development of this country.

Five years ago, when our railway system was placed under Federal control, its march of progress was halted and it has never regained its stride. Its development has not kept pace with the industrial development of the country because its revenues have not been sufficient to attract the additional capital necessary to finance the cost of normal additions and betterments to road and equipment.

The public is clamoring for lower rates, while existing rates are not high enough to produce the net railway operating income which, as determined by the Interstate Commerce Commission, the railways are entitled to earn. Still the tendency of the Commission is to reduce rates and there is no reasonable hope of increasing them.

Inadequate Railway Terminal Facilities.—Disregarding the temporarily bad condition of railway equipment resulting from the existing strike of the shop crafts, the only limitation on the volume of traffic which the railroads can move is due to the railway terminal facilities which are inadequate to take care of the traffic which easily could be transported over the main lines of railway.

Under existing rates, the line haul of freight would be highly profitable, if the revenue therefrom were not absorbed by constantly increasing terminal expenses. If the railways are to remain solvent and carry the traffic for which rail transportation is demanded, they must find a way, first, to reduce terminal expenses, and second, either to enlarge their terminal facilities or to pass more traffic through the existing facilities. How to do these things is in my opinion the most important problem before the American people. I have devoted to it all the time I could spare from my regular duties during the past 15 years, and have arrived at the definite conclusion that the problem can be solved only by remedying the following evils:

First—Too low compensation paid to the railways for carrying parcel post and express on expensive passenger trains.

Second—Lack of organized collection and delivery service, which lack makes it necessary to furnish unreasonably large and expensive freight terminal facilities, and unreasonably large supply of freight cars.

Third—The use of box cars for the transfer of l. c. l. freight between railway stations in large terminal areas. The trucker could perform that necessary service more quickly and economically. Thousands of box cars thereby would be released from an unprofitable service and would substantially increase the carrying capacity of the railway.

Fourth—The use of box cars as trap cars, for moving l. c. l. freight through terminal areas for industries which have rail connections, and the iniquitous absorption by the railways of trap-car, subway, and lighterage expenses, which is equivalent to furnishing free cartage to the favored few large traders, in discrimination against the average trader, who is obliged to provide or pay for his own cartage.

Fifth—The operation of branch lines on which the traffic is too light to sustain railway transportation and which could be served better and at far less expense by the motor truck.

Advantages of Co-operation Between Railway and Motor-Truck.—The most important field of co-operation between the railway and the truck is offered by collection and delivery of l. c. l. freight in large cities. Comparatively few trucks are used in this service, first, because there is no co-operation between the truckers themselves, and, second, because there is no co-operation between the trucker and the railway. As the collection and delivery of l. c. l. freight in large cities is now conducted the delays to trucks in reaching the station door and in loading and unloading the truck make unprofitable the use of the truck in station service, so that by far the greater part of this service is performed by horse-drawn vehicles. Truck transportation is only profitable when the truck can be kept moving the greater part of the time.

Notable experiments have been tried in the United States for handling the collection and delivery of the freight of one railway company in a large city and, so far as I have been able to learn, none of them have been successful. No single railway company receives and delivers freight from and to every part of a large city in sufficient volume to make profitable the collection and delivery of such freight by a trucking organization. I am satisfied, however, that the combined l. c. l. freight of all the railways reaching a city could be collected and delivered by a properly equipped single trucking organization, working in full co-operation with the railways, at less cost than is now paid by the traders in that city for their cartage, and still yield a reasonable profit to the trucking organization.

For many years the Canadian railways have furnished collection and delivery in the principal cities of Canada, under separate cartage tariffs. The president of one of the largest Canadian railways is my authority for the statement that his railway could not possibly handle its traffic through its present terminal facilities without well organized collection and delivery service.

Collection and Delivery System in Great Britain.—In England, Scotland, and Wales the railways are furnishing collection and delivery at practically all of their stations. Knowing this, I devoted a few days last year and several weeks this year to intensive study of the collection and delivery service in England and Scotland, principally in the great cities of London, Manchester and Glasgow. I was given exceptional opportunities and assistance for the investigation at close range of the terminal operations of the principal English and Scotch railways. As you perhaps know, the general manager is the chief executive officer of a British railway. The several general managers with whom I discussed these problems in Great Britain were unanimous in expressing the following conclusions:

1. That the collection and delivery of freight, at terminal cities and in large industrial centers, by a single

trucking organization, is absolutely essential to the most efficient operation of freight stations and that with such a trucking organization co-operating with it, the railway company may control the time of collection and delivery of freight and is able to operate its stations throughout the 24-hour day if necessary, and to use the same platforms and forces for handling in-bound and out-bound freight.

2. That collection and delivery can be furnished under a separate tariff at rates high enough to produce an actual profit from the cartage operations, after paying all expenses, and low enough to induce 95 per cent of the traders to avail themselves of the organized collection and delivery service rather than to perform it themselves.

3. That in England, where the general conditions are substantially like those in New England, the railways and the traders have prospered under unified cartage systems, without any substantial additions to station facilities.

In all of these conclusions of the British railway managers I heartily concur and I believe they ought to be adopted by American railways.

Comparison of Terminal Operations in U. S. and England.—Contrast the operations of a large terminal freight station in the United States with a typical British "goods" station.

In this country the in-bound freight is handled over one set of platforms by one working force and the out-bound freight is handled over another set of platforms by another working force. Each set of platforms and each working force is operated through the entire business day, as freight is taken away from the in-bound station and received at the out-bound station during the entire day. The in-bound platform is piled up with freight awaiting delivery, interfering with the movement of freight across the platform. When the in-bound cars are unloaded they must be pulled out of the station and set into the out-bound station for loading the following day.

In a typical British station the same platforms are used to handle not only the in-bound and out-bound traffic but also a third class of traffic and they are operated through the entire 24-hour day.

When the day force goes on duty at 8 a. m., a line of cars loaded with in-bound freight is standing on one side of the station platform and a continuous line of trucks or "lorries" are backed up to the other side of the platform. The city is divided into districts and the freight for one district is loaded into one or more lorries, there being more lorries at the platform than there are districts in the city. As soon as a lorry is fully loaded, a driver is summoned by telephone from a nearby stable. He comes with a heavy Clydesdale horse and drives away with a 3-ton load to the proper district, where he makes delivery. When one lorry is loaded and driven away, another empty lorry is backed into its place, loaded and driven away.

Before noon all of the in-bound freight has been removed from the cars and delivered by lorries. At 1 p. m. the station platform is clear and ready to receive the out-bound freight which is collected and delivered at the station by the same drivers who delivered the in-bound freight in the forenoon. All of the out-bound freight is collected before 5 p. m., loaded into cars and dispatched before midnight. The platform is again clear and ready to receive the heavy fish and vegetable traffic which begins to arrive at 1 a. m. and is delivered at the markets before 6 a. m. At 8 a. m. the platform is again clear and the empty lorries are standing at the platform ready for the in-bound merchandise.

For collection and delivery in this country, demountable truck bodies, trailers, or semi-trailers doubtless would be used instead of the British lorries and gasoline or electric tractors would be substituted for Clydesdale horses. On our station platforms we doubtless would use 4-wheel trailer trucks drawn by electric tractors instead of the old-fashioned 2-wheel trucks which are used in Great Britain. In fact, I left that country with the firm conviction that with our American methods applied to the British system of collection and delivery, much greater efficiency would be obtained and better service would be rendered than is now rendered in Great Britain.

Three of the great English railways have combined their collection and delivery service in London with most satisfactory results and I was assured by the manager of the combined service that, if all of the railways reaching London would join in the combination, he could effect even greater economies than he had already accomplished.

I am well aware that the average railway manager in this country fears to encourage the establishment of collection and delivery service because of the danger that the railway will be required to pay the cost of the service and thereby increase the terminal expenses. I would not recommend that the collection and delivery service be forced upon the trader, but rather, that it be offered to him under separate cartage tariffs at rates which would be less than the trader's present cartage expenses. I believe that the result would be the same as it has been in Canada and Great Britain where the collection and delivery service has been accepted voluntarily by a large majority of the traders.

Collection and Delivery of Carload Freight.—There is a second field for co-operation between the motor truck and the railway, which would require a more radical departure from present methods than the one just mentioned, but which would produce even more beneficial results to all parties concerned. It is the organized delivery of carload freight from public team tracks in large terminal areas.

As already stated, this freight is now loaded, unloaded, collected and delivered by the trader, or at his expense. In different cities the trader is allowed from 2 to 5 days within which to unload cars after he has received notice that they are ready to be unloaded.

Generally speaking, there is a shortage of team tracks in the central districts of large cities and it is next to impossible for the railroads to furnish additional team tracks. Cars must be held in the outer yards until there is room for them on the team tracks, and then they must be held on the team tracks until it is convenient for the trader, or his trucker, to unload them. The necessary consequence is that large terminal districts are full of idle cars, and I think it is safe to say that the average time that box cars are delayed at the Port of New York and in the switching district of Chicago is 10 days per trip. If all of the freight cars which carry loads into the Port of New York, the switching district of Chicago, and other large terminal areas could be unloaded on the day of their arrival, they could be loaded out on the same day, or the following day, and the present freight car equipment of the railways would be sufficient to meet all transportation needs for several years to come.

Competition between the railways to outdo each other in affording privileges to the traders has brought about a situation which is crippling the freight car supply and thereby is injuring the trader more than he is benefited by the allowance of an unreasonable time within which to load and unload carload freight.

At the present time there is a serious shortage of freight car equipment in all parts of the country. The railways, the commercial organizations and public authorities are urging the traders everywhere promptly to load and unload cars in order to reduce the idle time of freight cars and supply the crying need for more cars to move accumulated freight. Notwithstanding these appeals, the car shortage is not being substantially remedied.

In my judgment, a new system of delivering carload freight must be adopted and it will require the co-operation, not only of the railways and the truckers, but also of the traders, warehousemen, the Interstate Commerce Commission and the State Utilities Commissions.

The rules relating to free time for holding loaded and empty cars, awaiting the convenience of the traders, should be so modified as to insure the unloading of cars within 24 hours after they are ready for unloading and the loading of cars within 24 hours after they are placed at the disposal of the trader.

I realize that this is a radical change and would deprive the trader of a substantial amount of free storage which he has always enjoyed and would require him to pay warehouse charges on such inbound freight as he is unable to receive on the day of its arrival. This apparent disadvantage, however, could be, to some extent, offset by cheaper cartage furnished by an organized collection and delivery service and the warehouse charges might be reduced substantially by co-operation between the railway, the trucker and the warehouseman.

The importance of cutting down the idle time of cars is shown by the fact, which I believe can be established, that the average time required by a freight car, in carload freight service, to make a round-trip is about 20 days, and of that time, the car is actually moving in line haul, loaded or empty, only 2 2/10 days, and it is actually earning revenue only 1½ days out of the 20 days required for the round trip.

Branch Line Service.—Another field for the profitable use of the motor truck is the transportation of freight between communities which are served by branch lines of railway, on which the traffic is too light to pay the expenses of any kind of railway transportation. Such branches are almost innumerable and are scattered over every part of the country. They were built before motor transportation was perfected and, undoubtedly, they have performed a necessary public service, but they have outlived their usefulness. The transportation furnished over such lines could be performed better and more cheaply by motor conveyances over the public highways. No more such branch lines ought to be or will be constructed, if the trucker will take over the field and occupy it intelligently and efficiently. In recent years I have known of several cases where railways seriously have contemplated the construction of branch lines to reach small cities and towns, and, on investigation, have found that they could better afford to establish their own truck service, and the proposed branches have not been built.

I will go further and state that I think that all such money losing branch lines, along which transportation by truck over existing highways could be furnished at less expense, should be abandoned. The better and less expensive truck service should be substituted by the railroad company, if the trucker will not occupy the field.

Who Will Benefit Through These Changes?—Five parties are interested in bringing about the changes we have outlined:

The whole public would be benefited in that the city streets would be relieved from the congestion caused by wagons and trucks carrying small lots of freight to and from the railway stations. The new rural highways would last longer, as the co-operation of railway and truck would put an end to long-distance trucking.

The trader would get better service at less cost.

The motor-truck industry and existing cartage companies and private truckers who would co-operate with the railways would vastly increase their field for profitable operation.

The warehousemen would profit by the additional storage now furnished by the railways.

The railways would cut down their terminal expenses and would increase their capacity for service.

The trucker has a distinct advantage over the railway, in that highways are constructed by the general public, through some form of taxation, while the railway is constructed at the private expense of the railroad company.

In the early history of this country, public lands and moneys were contributed to a few railway companies, to induce them to build railways in territory which greatly needed transportation, but such donations have long since been repaid by the enhancement in the value of the taxable property, whose development has followed the railroad and would not have occurred without the railroad.

The railway, through taxation, pays a large share of the cost of constructing and maintaining highways, while the trucker pays no part of the cost of constructing or maintaining the railway. If the trucker is to compete with the railway, either he should pay a substantial part of the cost of constructing and maintaining the highway or the railway should be relieved of taxation for highway purposes.

If, however, the trucker, first, would perform that part of transportation furnished by the railway at an operating loss and on which the trucker could make a reasonable profit; second, would cease to compete with the railway for the traffic which the railway can carry at a profit and on which the profit of the trucker is very doubtful; and third, would co-operate with the railway in handling traffic which requires transportation both by rail and highway; in other words, if the truck would supplement the railway service instead of competing with it, then it would be to the interest of the railway that the expense of the trucker should be reduced to the lowest possible limit, and, in my judgment, the railway could well afford to pay substantial taxes for highway purposes and to make no objection to the free use of the highway by the trucker.

There is a steady and, for the trucker, an alarming growth of public sentiment in favor of imposing upon the trucker a more substantial part of the cost of maintaiing and renewing public highways, which, it is claimed, are destroyed by heavy trucks almost as fast as the highways can be constructed. If the public were satisfied that the truck was only used as a common carrier where the railway could not furnish as good and as cheap a service as the trucker furnishes, I believe the public would cease demanding that greater burdens be placed upon the trucker, which would increase the cost of his service.

No Single Scheme of Operation Will Fit All Terminal Situations.—The situation at the Port of New York seems to me to demand the use of motor trucks with demountable bodies or trailers to move the freight by way of ferries and city streets between railway terminals on the New Jersey shore and inland off-track stations in the different industrial centers of New York. The movement across the rivers is now made principally in freight cars on car floats. By the use of ferry boats and inland off-track stations, the railroads would be able to release large holdings of very valuable dock property on both sides of the rivers and such property would become available for the docking of ocean steamships for which there is great demand.

The inland stations could be constructed on much less valuable property and if used as universal stations for all railways and steamship companies they would offer superior advantages for upper floors which could be devoted to warehousing or other industrial purposes. I have been assured by New York real estate men of great experience that they would undertake to secure sites for such inland stations in all parts of New York and the construction thereon of buildings in which the first floors would be adapted for use as railway stations. They were willing to guarantee that the station floors would be leased permanently to the railway companies at nominal rentals on condition that the occupants of the upper floors might have access by elevators to the station floor for the receipt and delivery of freight, without any expense for cartage.

All this traffic now passes through the streets of New York. An organized truck service would substantially reduce the number of vehicles on the streets and the cost of the service would be much less than the expense of the present car float operations.

The situation at Chicago is more complex. The distances are so great and the railway systems so completely cover the city that I think the railways must supplement the truck service for movements over long distances.

In Cincinnati an organized truck service is in operation and conducts most of the transferring of freight between the city stations of all the railroads centering there. All stations are equipped with the necessary machinery for handling loaded and empty 5-ton, demountable, truck bodies, which are loaded and unloaded on the station platform and promptly moved by chasses, under the control of a truck dispatcher. This station to station service could easily be extended to the various industries. In fact, some of the largest traders in Cincinnati already have requested such extension of service.

At St. Louis, organized motor truck service with trailers and semi-trailers has long been in operation between the freight stations at East St. Louis and inland stations in St. Louis. The service conforms closely to that outlined for the Port of New York, except that the trucks cross the river on high bridges instead of ferry boats.

At St. Paul and Minneapolis, the Great Northern and Northern Pacific railway companies for many years have used large box cars as freight stations for out-bound l. c. l. freight in different parts of both cities. When the cars are loaded they are switched to a common transfer station about half way between the Twin Cities, and there the freight is transferred from the station cars to line cars for any destination on either railroad.

The Chicago, Milwaukee & St. Paul Ry. Co. is using a similar service at the Twin Cities. The president of the latter company, several years ago, assured me that, by substituting that service for the separate stations previously used in each city, his company had been able to move its increasing freight traffic with 40 per cent less cars than previously were required for movement from separate stations in each city.

I believe that for every city there is a practical solution which, with the full co-operation of railways and trucks, would result in the movement of freight through the city stations as soon as it arrives there and would thus enable the railway to furnish much more transportation service without increasing its facilities and without increasing its charges for transportation.

Conclusion.—The truck should supplement the railway and not compete with it. Wherever complete transportation can be furnished by the truck more efficiently and cheaply than by the railway, the truck should be used. Wherever the railway service is adequate and profitable and less expensive than truck service, the railway should perform the service. Where the best and cheapest service can be furnished profitably by the railroad and truck combined, the railway and the trucker should co-operate in furnishing that service.

Effect of Rafting on Weight of Ties

The following figures from the September Cross Tie Bulletin show the effect of rafting on the weights of ties. The test was made on ten red oak ties:

	Lb.
Weight before putting in water	1,341
Weight taken out of water March 4.	1,701
Weight on March 10	1,620
Weight on March 16	1,562
Weight on March 23	1,503
Weight on March 30 ((30 days)	1,483
Weight on May 25, when they were treated	1.442

Ties were 25.9 lb. lighter when dry enough to treat than when first taken out of water.

Stripping Problems in Limestone Quarries

Methods Employed in the Shenandoah Valley Described in Bureau of Mines Monthly Report of Investigations

The U. S. Bureau of Mines has recently undertaken a study of limestone quarrying for lime manufacture, in connection with which a series of short papers on various phases of the industry will be issued. The first paper of this series, written by Oliver Bowles, mineral technologist of the bureau, has just been issued and from it we quote the matter that follows:

Solution Cavities.—The limestone of the Shenandoah Valley of Virginia and West Virginia are characterized by numerous solution cavities brought about by surface or subterranean stream erosion. Some form extensive caverns in which part of the dissolved calcium carbonate (limestone) has been redeposited as stalactites and various other ornate forms. Some of the caverns have been illuminated and opened to the public as commercial enterprises. In a few instances the cavities constitute a commercial asset in the valley, yet from the quarryman's point of view they are a decided disadvantage, for they constitute one of his hardest problems.

Clay Seams and Pockets.—The quarryman's difficulty is due to the occurrence, even at considerable depth, of erosion cavities, not in the form of open spaces but filled with red clay. These clay masses are troublesome, and their removal is costly. The problem is of general interest to all limestone quarrymen, for erosion cavities are characteristic of limestone deposits though they are not generally developed as much as in the district under consideration. In many quarries throughout the valley the stripped rock surface is very rugged, consisting of knobs or spires of rock with irregular cavities or cracks between them. Solution has not only honeycombed the surface but it has followed joints or other planes of weakness, and thus has dissolved cut seams or pockets many feet in depth. Masses of clay 30 to 60 ft. in width have been observed 80 ft. below the rock surface.

In general the clay pockets are very numerous at the surface, and are absent or greatly reduced in size at depths of 10 to 20 ft. Thus the bulk of the clay is usually found in the upper 6 to 12 ft. of the rock mass; in many quarries this upper zone contains as much clay as rock, or the clay content may exceed that of the rock.

Necessity for Separation of Clay.—Clay is a hydrous silicate of aluminum, hence if clay is burned with the limestone a lime contaminated with alumina and silica results. For certain uses a limited percentage of such impurities is permissible, but for most purposes a high degree of purity is demanded. It is apparent therefore that a clean separation is required, and owing to the large proportion and irregular occurence of the clay such separation is surrounded by many difficulties.

General Methods of Removal.—Two general methods are followed in removing the clay. The greater part of it may be stripped back before the ledge is blasted down, or clay and rock may be shot down together and separated later at the quarry floor. The first method is usually followed where a foot or more of solid clay lies above the highest points of rock. Where numerous knobs or ridges of rock are exposed at the surface, the difficulty of digging the clay from between the rock masses commonly results in the quarryman's following the second method—that of blasting down rock and clay together, and separating them while loading.

Merits of the Two Methods Considered.—Where a large volume of clay occurs free enough from rock masses to permit the use of such mechanical equipment as the steam shovel or dragline scraper it is undoubtedly wiser to remove as much as possible of the clay before blasting down the rock. If the rock surface is so extremely rugged that it is advisable to use hand tools only, the relative merits of the two methods are more difficult to judge. If rock and clay are shot down together, the intimate mixture makes separation slow and difficult. In rainy weather the clay adheres to the rock fragments, and the quarrying of clean rock becomes impossible. On the other hand, in cleaning out the pockets before blasting, the clay is fairly free of loose rock fragments, and the rock subsequently shot down is clean in either wet or dry weather. In loading dirt at the quarry floor, however, the laborer is required to lift it only high enough to clear the edge of the quarry car, in cleaning out pockets from the surface, clay must sometimes be raised 10 to 20 ft. Loading in the quarry is also much more rapid as the clay is loose, whereas the firm, undisturbed clay in the pockets may require excessive use of the pick, or may even require blasting; thus its removal is slow and expensive.

High Cost of Hand Loading.—Hand loading of clay is laborious, slow and costly. This fact is recognized by most quarry operators, but owing to the peculiar conditions in the Shenandoah Valley the method is still widely used. The cost of loading dirt at the quarry floor in 1922 varies from 15 to 25 ct. per cubic yard. Hand loading of clay at the surface varies from 30 to 45 ct. a yard. The latter figure applies to direct loading of clay from the bank to the car or dump cart. The cost may be very much higher where the clay is removed from deep cavities. At one quarry observed four men shoveled the same masses of clay to successively higher benches, and the fifth man loaded it into a dump cart. Under such conditions the cost might reach $1 or $1.50 per yard. Owing to the excessive cost of hand loading, and its wide employment in the Valley, the Bureau of Mines, though recognizing the difficulties to be overcome, urged upon operators the desirability of seeking more efficient methods. Improved methods now employed or proposed are discussed in the following paragraphs.

Hydraulic Method. — Hydraulicking is one of the most efficient methods yet devised for the removal of overburden. Water is pumped at high pressure, and is directed against the bank through a special nozzle. The method, however, is limited in application, as certain specific conditions must be met. First, there must be an adequate water supply. Second, the quarry must have proper drainage. The most favorable condition is where the natural drainage is back from the face so that the soil may be washed away in some ravine, or other depression, where no further handling is required. In exceptional cases the soil may be carried toward the quarry face. In a quarry near St. Louis, Mo., hydraulic stripping has been successfully employed where the soil is carried across the quarry to the river by aqueduct. At a cement plant in Virginia the clay is washed to the quarry floor where it is later loaded by steam shovel and removed in cars. It is unlikely that the hydraulic method can be employed profitably except in shelf quarries where automatic drainage carries off the water used in stripping. A third condition to be met is the availability of a suitable settling basin where the soil may be disposed of without covering adjacent property or contaminating streams on which other industries depend.

The hydraulic method has been used with success in the Shenandoah Valley, the cost of soil removal being not more than 12½ ct. per cubic yard. The Bureau has a record of a hydraulic stripping cost at a marble quarry in Tennessee, in 1916, of only 2 ct. per cubic yard. In the gold districts of California where some years ago hydraulic mining was widely used the cost of handling gravel was about 2½ ct. per cubic yard. As the actual gold value in much of the gravel did not exceed 3 to 5 ct. per cubic yard the cost of hydraulicking must have been kept considerably below this figure. At one of the large iron mines in Minnesota very extensive hydraulic stripping was conducted about 1914 at an average cost of 6.7 ct. per cubic yard, including upkeep and office expense. In the Florida phosphate fields hydraulic stripping of fine overburden cost 5 to 8 ct. per cubic yard in 1912. In the Tennessee brown phosphate fields hydraulic stripping some years ago cost about 7 ct. per cubic yard. At a Missouri cement plant quarry in 1916 hydraulic stripping cost, including blasting of hard soil, was about 7 ct. per cubic yard. Under 1922 operating costs these figures should be increased approximately 50 per cent.

Drag-line Excavator.—A drag-line excavator operated from a derrick arm has been used successfully in cleaning out clay pockets in Pennsylvania. The entire equipment is on a portable mounting, and the excavated material is loaded on cars just as when a steam shovel is employed. It cleans out shallow depressions fairly well, but some hand work is required in the deeper cavities. The lateral motion of the derrick arm gives the excavator a wide range and great flexibility of movement.

Clam-Shell Bucket.—A clam-shell bucket operated from a derrick arm or crane has been used to a limited extent in moving soil overburden. Its usefulness in removing clay from erosion cavities is not yet established, and further information is desirable.

Tractor Excavator.—A small tractor excavator widely used in road grading has been employed with success on eroded limestone surfaces in Pennsylvania. The dipper slides back and forth on an arm 12 or 14 ft. in length, which may be raised and swung aside for dumping into cars or wagons. The excavator is so equipped that the dipper may be lowered into a pit, loading as it is elevated toward the surface. Such an adaptation permits it to be used in cleaning out clay pockets.

Steam Shovel for Soil Only.—Several operators in the Valley have used steam shovels with success on very uneven surfaces. Rock projections so interfere with continuous operation that great patience is required, and the operator must be prepared for much lost time both in loading and in moving. The shovel will not excavate from deep pockets, hence much hand work must follow, but where a depth of several feet of clay is encountered, the steam shovel is much more economical than hand loading. The smaller types of tractor, or caterpillar shovels with dippers not more than ¾ yd. in size, are best adapted for such work.

The actual cost of steam shovel stripping varies greatly in different localities. In the Florida prosphate fields the contract price for steam shovel stripping was 20 ct. per cubic yard in 1912. At several cement plant quarries in 1916 and 1917 the cost of steam shovel stripping varied from 11 to 16 ct. per cubic ward including transportation to the dump. The Dolomite Products Company of Cleveland, O., in substituting a steam shovel for hand loading of soil overburden found that the daily cost of handling the same amount of material was reduced from $137.50 to $35 per day.

An interesting modification in the use of the steam shovel has been proposed, but has not yet been tried. It is suggested that rock and soil be blasted down together, the serviceable stone sorted out and removed, and a steam shovel employed to clean up the soil and waste on the quarry floor. All good stone in the waste material could be thrown aside while loading. The adherence of mud to the rock during rainy weather as previously mentioned is a disadvantage, but as waste is much more slowly loaded than good rock by hand methods, the proposed scheme has some merit.

Steam Shovel for Both Rock and Clay.—A method now being tried in the Valley, and which according to report has been successfully used elsewhere, involves the use of the steam shovel for both rock and clay in the upper part of the deposit. The great bulk of the clay in pockets and seam is usually confined to the upper 6 to 12 ft. of the limestone deposit, thus if a cut 6 to 12 ft. deep is made, the clay may be loaded into cars with a small tractor shovel having a ½-yd. dipper, and the rock masses drilled and blasted as they are encountered. The rock thus obtained may be loaded into separate cars, but it is not deemed advisable to do so, for it is difficult if not impossible to load clean rock with a steam shovel where rock and soil are mixed. As now conducted the surface cut is at the margin of the quarry excavation, and all rock masses encountered are thrown over the edge where they are loaded at the quarry floor. This makes possible a clean separation of rock and soil.

The method as thus briefly outlined is one of the most promising yet proposed, for it permits removal of almost the entire mass of clay with the steam shovel, and leaves the underlying limestone ledge relatively clean and well prepared for ordinary methods of quarrying.

Steam Shovel with Washing and Screening Plant.—One operator plans to erect a washing plant, and in the writer's opinion this is the best solution of the stripping problem in large quarries. Small operators probably could not employ such equipment profitably, but where 250 tons or more of rock are quarried per day, there is no evident reason why a washing and screening equipment could not be employed with profit. Most operators will admit that with present high wages the steam shovel is far more efficient than hand methods for loading either rock or soil. The great weakness of the steam shovel is its inability to sort the materials that it loads, and hand methods are employed because it is necessary to sort the stone according to size, and to separate it from the clay. The washing and screening equipment accomplishes the necessary sizing and purification of the rock, and thus permits steam shovel loading. Where a heavy overburden is encountered, the bulk of the material may be stripped separately as a preliminary operation, but all clay that occurs in close association with the rock may be separated in the washing plant.

At one lime plant in Pennsylvania the rock is all loaded with steam shovels, passed through a jaw crusher with an 8-in. opening, and carried in a pan conveyor to a rotary screen. The larger sizes are conveyed to the kilns, and the smaller sizes to railroad cars for flux or road work. With the addition of nozzles and other necessary equipment to wash the stone during its passage through the rotary scren, this type of plant would be ideal for rock mixed with clay as in the Valley region. It would also prepare the way for better utilization of the smaller sizes of stone, materials which are now mostly mixed with soil and thrown away as waste.

Removal of Clay from Deep Erosion Cavities.—Occasionally clay-filled cavities of large size are encountered. In one quarry in Virginia a mass of clay 60 ft. across reached to the bottom of an 80-ft. excavation. On account of the slow hand methods employed, its removal seriously curtailed the output of the plant for two years. Obviously it would have been easy for a steam shovel, operating on the quarry floor, to remove such a mass in a few weeks.

Deep erosion cavities often occur in places where it is difficult or impossible to employ ordinary mechanical methods of removal. Several instances have been observed where a succession of laborers shovel the clay from bench to bench until it is finally thrown to a point from which it can be loaded into cars or dump carts. Such methods date back to antiquity, and involve a labor charge that is prohibitive under modern wage conditions. If a clam-shell bucket, dragline excavator, or similar device cannot be employed, it is suggested that the soil be mechanically elevated by means of some type of wagon-loading equipment now so generally used. A portable belt or bucket elevator is easily placed in position, and may be operated at low cost by electric motor or gasoline engine. With such simple equipment two men could easily do the work of 6 or 7.

Underground Methods.—One operator has solved the stripping problem simply and effectively by removing the lower ledges of high grade limestones without disturbing the overlying inferior rock and clay. From the quarry wall an entry is driven into the ledge, and drifts are projected right and left. Certain disadvantages are connected with mining limestone, and the method is to be recommended only where a sound roof is obtainable, and where an excessive thickness of soil or waste rock overburden is encountered.

Summary.—As a result of his observations the writer concludes that removal of the overburden is unusually difficult in limestone quarries in the Shenandoah Valley, and that stripping expense is consequently one of the chief items of quarry cost. It would be very helpful to the Bureau to obtain from operators who have the data definite figures showing the proportion stripping costs bear to total quarry cost.

The writer is convinced that if mechanical means of removing the overburden were more generally employed the stripping expense would be greatly reduced. Stripping costs in the Valley by hand methods vary from 20 to 45 ct. per cubic yard for average conditions and are very much higher where clay removal is exceptionally difficult. The cost of hydraulic stripping varies from 3 to 11 ct. per cubic yard, while steam shovel operation costs from 16 to 30 ct. per cubic yard.

A decision as to the best methods and types of equipment to be used in stripping is open for discussion, and it is hoped that many operators will act upon the suggestion that they submit their ideas to the Bureau of Mines.

Cubic Contents of Various Sizes of Ties

The following table from the September Cross Tie Bulletin gives the comparative cubic content of the various sizes of ties (and width of face) calculated on the basis of a 6 in. by 8 in.—8 ft. tie with an 8 in. face taken as 100 per cent.

6 in. x 8 in.—8 ft. with 6 in. face equals 4,416 cu. in. equals 95.83 per cent.

6 in. x 8 in.—8 ft. with 7 in. face equals 4,560 cu. in. equals 98.96 per cent.

6 in. x 8 in.—8 ft. with 8 in. face equals 4,608 cu. in. equals 100 per cent.

7 in. x 8 in.—8 ft. with 7 in. face equals 5,327 cu. in. equals 115.66 per cent.

7 in. x 8 in.—8 ft. with 8 in. face equals 5,376 cu. in. equals 116.7 per cent.

7 in. x 9 in.—8 ft. with 8 in. face equals 6,000 cu. in. equals 130.22 per cent.

7 in. x 9 in.—8 ft. with 9 in. face equals 6,048 cu. in. equals 131.25 per cent.

For 8½ Ft. Ties Add 6¼ Per Cent.

The above figures are approximately correct.

Cost of Horse Maintenance at Fitchburg, Mass.

During 1921 the city of Fitchburg, Mass., maintained 23 horses at its stables. The total cost for the year, according to the annual report by David A. Hartwell, Commissioner of Public Works, for hay, grain and straw, harness repairs, shoeing and stable labor was $18,263.96. On the basis of 300 working days in a year, the cost per horse per day was $2.65. In 1920 this cost was $3.12; in 1919 it was $2.29 and in 1916 it was $1.26.

26-Mile Subway Ride for 5 cts.—A subway ride of 26.78 miles for one five-cent fare—the longest in the world for the price—is now possible in New York. Passengers entering the Intherborough Rapid Transit Company's subway station at the end of the new Livonia avenue extension in Brooklyn, near the Queens County line, could ride through Brooklyn, Manhattan and the Bronx to 241st street and White Plains road.

The Principles of Organization in Railroad Work

Address Presented Oct. 18 at the Annual Convention of the American Railway Bridge and Building Association

By R. N. BEGIEN,
General Manager, Baltimore & Ohio R. R.

It is important that there should be organization in all branches of railroad work, and while my remarks cover a broader field of railroad organization than are embraced by work handled by members of this Association, the governing principles are the same whenever applied. There is nothing new in the ideas presented here. However, it is a good plan to set down ideas in such a way that they may be connected. We know all of the facts mentioned, but we will find it to our advantage to think of and discuss them collectively instead of disjointedly.

Service the Essential Thing.—On a railroad, service is an essential thing. Without it business will be diverted.

Good organization makes good operation.

Good operation makes good service.
Good service makes good business.
Good business makes good earnings.

Remember that good service is possible and that better service than the competitor gives will win the business.

The most important influence in the direction of good service, high earnings and low expense is good operation. To go further let it be remembered that maximum earnings and minimum expenses are impossible unless the railroad is carefully organized, and officers and men thoroughly understand that deviation from the rules of proper procedure will not be tolerated.

Every officer should clearly understand for what duties and results he is held responsible. He should not be excused from such responsibility on any pretext whatsoever. His superior should deal with him only, and he should never run around or ignore any officer, subordinate or superior. If responsibility is definitely fixed from top to bottom and a definite plan of action is made, an organization of ordinary men will accomplish far better results than the same number of brilliant men, each working hard to carry out his own ideas. Last week in New York the World Series was played between the New York Giants and Yankees. One team was composed of an aggregation of star players while the other was a well organized ball team. There is no better example of the triumph of a good organization over a collection of superior individuals than was afforded by this World Series.

It is not possible to realize a high standard unless it is known what constitutes a high standard. President Lowell, of Harvard, has said that a good standard of action to be governed by could generally be determined by thinking of what the man you admire most in the world would do under the circumstances. In a railroad organization some one has to fix the standard. Only one person can do it and he is the chief executive. It is important, therefore, that he should be a man who knows what a high standard is. If he selects a staff of men who are able to measure up to his ideals and who knows what they are, he has made good progress.

The Standards of an Executive.—Each man of the staff has his own special department, but he must conduct his department in such a way as to meet the standards of his chief. These may be, in part:

(1) A careful attention to justice.

(2) Right adherence to the plan of organization.

(3) Good service to the public.

(4) Correct understanding of the responsibilities of official position.

(5) Efficiency of operation.

(6) Calm and courteous consideration of subordinates.

(7) Consistency of action.

(8) Dependability.

The foregoing are illustrations of the standards of an executive. How far he may go beyond their inception and exposition depends entirely on his knowledge of the qualifications of his staff. If he has selected his aids with a view to having them carry out his plans and ideas it may be necessary to go only into the question of standards, without consideration of methods of attainment. Instruction in method is generally necessary, however. Promotion generally comes to a man as soon as he has learned the importance of correct standards and organization, so that new men have to be educated constantly. Above all, a subordinate should never see that the standard of his chief has been lowered.

Accurate Sense of Justice as Asset.—An accurate sense of justice is a valuable asset for any man. Without it a man is disqualified for an executive position. Some men have an excellent idea of justice when they are calm, but when they are disturbed in mind become unjust. A superior should never frighten a subordinate. If the chief makes no impression on his subordinate, then it is evident that the latter has but little regard for what he says. If his remarks do make an impression they will probably be passed on to subordinates. If an officer is calm, courteous and definite it will be easy to be just.

All men know how they feel after they have an interview with the "boss." If the chief is cross or excitable he usually says things he does not mean and leaves his subordinate with an uncertain feeling of what is required. He does not fill his man with a desire to accomplish much good, but he does often make him realize that his job hangs by a thread. He thus has a confused man who is frightened. Such a man will usually pass it on to his subordinates and it will go on down the line.

The length of time that it takes to disorganize a job will be in direct proportion to the number of times the "boss" explodes.

Six Steps from Bottom to Top.—An organization of more than 10,000 men needs only about six steps from the top to the bottom. It will be conceded that one man is capable of supervising the actions of ten men. In addition he can educate them in the standards of his chief.

Look at this:

1	chief officer
10	vice chiefs
100	heads of departments
1,000	subheads
10,000	bosses
100,000	men
111,111	Total

Some railroads have more steps than are shown; some have less. Think of it; the laborer on a section has only five steps to the presidency of a railroad. There being only six grades from top to bottom, only four men have to interpret the words of the president before the man on the track is working according to the standards laid down by the president.

Selection of Subordinates.—The selection of the subordinates in sequence is a most important matter. If a 100 per cent officer selects 100 per cent assistants the result is 100 per cent performance. If a 90 per cent general superintendent selects a 90 per cent superintendent, and he selects a 90 per cent division engineer, who employs a 90 per cent supervisor, who hires 90 per cent foremen and 90 per cent men, the result is 90 per cent by 90 per cent by 90 per cent by 90 per cent by 90 per cent by 90 per cent, or a 53 per cent result.

It should be remembered that the highest officer is the standard bearer and his men are rarely ever any bigger than he is. In other words, it is hardly possible for a 90 per cent officer to have a 100 per cent assistant for any length of time. They would probably change places if the relation was true, unless the chief raised his own standard to 100 per cent. The foregoing illustrates the importance of highly efficient officers at the top.

Men Are Largely What We Expect Them To Be—It is perfectly evident to any one who gives the matter thought that if a subordinate feels that a mediocre performance is satisfactory to his chief, he has no incentive to produce more than a mediocre performance. Much can be gained by expecting a great deal of subordinates, as they will then make an effort to realize what is expected. A railroad is a highly organized body. Unless care is taken in placing competent supervision in every part of the oganization, the effect will be felt in other parts of the organization. An expensive and expert staff might evolve fine plans for economy, but they could not be carried out by a disorganized force. Proper organizations will make expenses lower and earnings better at once, for it will then be possible to carry out a plan. It is important to remember that if a feasible plan cannot be carried out it is nearly always due to defective organization.

For example, a bridge gang repairing a bridge may delay operation to the extent that the effects are felt over the entire railroad. It is not unusual for a bridge gang, and in fact, those who are over bridge gangs, to feel that the railroad is operated very largely for the purpose of supporting the bridge gang, while we all know that the work of gridge gangs is entirely subordinate to the principal function of running a railroad, and that is handling of cars. From an economical standpoint it is always cheaper and better to delay the work of the bridge gang than to allow the bridge gang to delay the work of the railroad in serving the public.

In order to follow the matter up a

little more closely let us suppose that a gang of men who are placing bridge ties on a bridge delays freight and passenger trains during progress of the work. On account of these delays the use of power is not as effective as is possible, and if business is heavy, terminals may become congested from power shortage; and, as the congestion increases, efficiency decreases, expenses go up, the service becomes inferior and presently we are adding clerks in the office of the superintendent to explain to the public why we are not doing better. While it is not likely that a single case of delayed movement by a bridge gang would cause as much confusion as indicated here, it is clear that on a division where delays of this nature are permitted to occur others of the same kind in other branches of the service will cause a multiplicity of trouble.

It is not enough that an officer or a sub-officer is competent in the discharge of his own immediate duties; that is, competent in the discharge of those things which he personally performs. It is his chief duty to see to it that his force is competent, able and willing to do the things that are assigned to them to do in the best possible manner, and if he has not such men he is negligent in the most important part of his duties.

Securing Competent Staff of Subordinates.—Men should not be replaced indiscriminately, as it is often a fact that little good is accomplished by making a change. It should first be determined that a more suitable man than the one at present occupying the position is available, and the one who is now occupying the position cannot be made available by proper instruction. If men are made to feel that nothing but a high standard of performance will be satisfactory, they are bound to improve.

Therefore it is important to do the following things:

1. Study the staff with a view to knowing that they are performing their duties properly.
2. If they are not performing their duties properly, can they be instructed in such a way as to improve them?
3. If they are not suitable men for the positions which they are now occupying, and cannot be made to be suitable men, is there any one who is suitable, or can be made suitable?
4. Have subordinates been impressed with the fact that they should expect the same things of their subordinates as is expected of them?
5. Make subordinates feel responsible for the results in their departments. Encourage them in every possible way to take responsibility unto themselves. Do not spare praise in cases of successful administration, and in cases of failure try to find out what is the matter and help them work out a solution of the problem.

Every officer should understand that it is not sufficient to merely state that the cause of some failure to properly perform a duty was that some of his subordinates did not carry out instructions. If the organization is a proper one, excuses of this kind would gradually disappear.

Assignment of Duties.—In a divisional organization, the superintendent should assign each member of his staff to definite duties and definite territories wherever possible. The object of such assignment is for the better delegation of work and for the fixing of specific responsibility. The chief of each branch must feel that the results to be secured are strictly up to him. On the other hand, he should not be hampered in his work, and except that he should conform to certain standards which are laid down by his superior officers, he should be allowed to use his judgment, which is equivalent to asking him to exercise his ingenuity.

No officer should fall into the habit of dodging an issue. In his dealings with subordinates or others he should never speak of having referred a question at issue to any one for a decision. To others his own judgment is the only one that should be asked for or should be given. If it should become necessary for him to ask for a ruling or advice, that should be a matter strictly between him and his superior officer.

Appointment of New Officers.—New officers may be appointed for various reasons. When the object is to secure a betterment of operation, the course of procedure becomes of interest. It is important that new officers and employees be instructed in their duties before being allowed to fill a position. One naturally thinks that all new officers and employees are instructed in their duties prior to appointment, but it is too often the case that this is not a fact. It is true that a trainman or engineman, and some other classes of employees, are handed a book of rules and are examined upon them, but that does not constitute instructions in their duties. Good men often fail to fill positions on account of the fact that they are not instructed. Failure may occur on account of being over-zealous, or backward to the point of laziness.

During the war when we were employing many unskilled men, I recall a case where a boy was packing journal boxes in a yard. His hands were covered with gloves and he was scraping the bottom of the bucket for oil and waste, with the result that his gloved hand could not detect whether there was grit in the oil or waste. An officer who happened along found that in the bottom of the bucket there was considerable sand, so that the boy was pushing into the box a gritty combination of oil and waste which would certainly result in a hot box a short distance out on the line. He was questioned as to whether he had been instructed in such matters, and he stated that he had not. He further stated that he had not even been visited by the foreman since he had been on the job—a matter of four or five days. The superintendent of motive power instructed the boy how a box should be packed and took steps to see that future new employees receive proper instruction. But the main point involved is that it should not have been possible for an employee to undertake a new job without instructions, and it is my opinion that the blame for such a condition extended from the top to the bottom of the whole divisional organization.

If a man is fit to be advanced at the start he generally is able to further advance, and it is a serious reflection on his superiors if he fails. He must not be allowed to fail; it is the duty of his superior to train him, and it should be impossible for men to be good men for a time and all of a sudden be discharged or demoted as unfit.

The Personnel the Last Thing to Be Disturbed.—Notwithstanding the importance of organization, the personnel is, generally speaking, the last thing which should be disturbed. Where improvement is demanded it is better to mould the existing personnel into a proper organization and then see if they can be brought up to the standard as individuals. Where there is disorganization it should be remembered that men of ability are often not able to work to any degree of efficiency on account of this. When the form of organization is improved the efficiency of the individual has a chance to assert itself.

Executives Should Form Habits of Concentration.—Many a good idea is lost sight of because nothing is done about it. It is often true that the man who has the idea cannot execute it, and the man who can execute it does not take the time to understand it. It is necessary for every executive to form habits of thoroughness and concentration that will make it possible to carefully compare values. It is far easier to let things go along as they are than to organize and put into effect new ideas, but new ideas must be carried out. When an officer thoroughly realizes that betterments are possible in almost all operations he has reached a satisfactory starting point.

It is certain that if his mind is made up that present conditions cannot be improved, he will waste a lot of time trying to prove that he is right. The first thing that an officer needs is the desire to accomplish things. A great personal desire to accomplish something is the strongest moving impulse that is known. It is greater than fear of punishment or hope of reward.

Where did you ever see a boy who could not go to the circus if he really desired to go. Only a short time ago a ragged boy appeared in one of the boxes at a ball game where seats cost the highest price, and in answer to an inquiry said that he had been thrown out of the grounds five times before he finally made it, but he was glad he had a good seat (not that a poor one would not satisfy him). He enjoyed the game with enough spirit and noise to show that he had entirely forgotten the difficulty of getting into the grounds.

Some men are skillful in carrying out their own ideas but have difficulty in getting into the proper frame of mind to carry out the ideas suggested by another. Many examples of this may be recalled. It is less difficult to get an idea carried out if by the power of suggestion a man may be led to believe that he himself originated it.

Discipline Should Be Firm But Not Harsh.—Adhere rigidly to the contract if there be one. In dealing with organized labor, do not adopt an air of antagonism. Organized labor is here to stay, and there are features in its favor that may be and can be turned to the advantage of the railroad company, or any other company employing it. The wide influence of these organizations holds down complaints from individual employees and has standardized practice in the discipline of men that is not without benefit to the employer. Rates of pay and working conditions may be the subject of controversy, but the local officer is chiefly concerned with the administration of the rules as laid down in the contract.

In dealing with committees, courteous treatment and a disposition to hear their side of the case fairly will materially help the relation of officers and employees. It is not strange that the interpretation of the contract should be the subject of dissension. The contracts and their interpretations have grown in size and complexity. It should be remembered that there are thousands of lawyers who make a living by telling citizens what are their rights under the constitution of the United States and its various branches and interpretations. It could hardly be supposed that a few railroad men could draw up anything as complicated as a wage schedule without serious differences of opinion The foregoing is largely fundamental; but it must be realized that until the fundamental conditions have been made correct it will not be possible to plan economies and carry them out successfully. Even then it should be remembered that large organizations absorb changes slowly. To get best results—

First—Take up one thing at a time and correct the trouble in that.

Second—With each difficulty overcome other things will be benefited.

Third—Work slowly enough to observe fully the effect of innovations. Do not expect results too quickly. Quick results may tend to disorganization.

Handling the Rank and File.—It is possible that officers think a great deal of their own attitude toward men of the rank and file and pay too little attention to what employees think of the officers and the company in general. It is certain that if a man likes his officers and is proud of the company for which he works, he will do much better work and form a better part of the whole organization than if he is dissatisfied and displeased with his "boss."

The man of the rank and file knows but little of the officers at the head of the large organizations. He deals entirely with his foreman, and it is generally the foreman, or his boss, who gives him his idea of the company or concern he is working for. Since the man under discussion, in many instances, is the one who performs the manual work, for the purpose of getting results it is most important that he should be handled well and be in a proper frame of mind.

The laboring man prizes most good working conditions, a steady job, a boss who knows how to handle men properly, and delivery of his pay envelope with regularity. In times of stress I have seen labor troubles of considerable size generated by failure of the paymaster to deliver the pay envelope on time, and it is worth the earnest thought of men in charge of organization to make a plan that will result in the men being paid with regularity.

Some of these things may appear to be of minor importance from the point of view of an official, but they are of the greatest importance to a large percentage of men working for a company. In work such as our, results are secured through the good handling of men and the best results are never secured without it. That is my reason for calling attention to, and listing up a few of the things which all of us know.

Railroads Show Increase in Net Operating Income.—The principal railroads of the country during the first nine months of the present year had net operating income returning 3.96 per cent on their tentative valuation, according to a statement issued by the Association of Railway Executives. This net income amounting to $529,413,000, compared with $393,793,000 during the corresponding period last year.

Railway Ferry Cradle at St. Louis Has New Features

The Missouri Pacific Ry. transfers a large part of its traffic across the Mississippi river by means of a car ferry. The traffic handled in this manner amounts to as much as 600 cars a day, including a considerable number of hopper bottom coal cars of 55 to 70 tons capacity. The marine equipment consists of a 4-track, 26-car steel barge, operated by a stern wheel tow boat. Owing to the wide variation in the stage of water in the Mississippi river, one troublesome detail in the handling of the ferry traffic concerns the method provided for transferring the cars from the tracks on the river bank to the ferry. This is commonly accomplished with the aid of a cradle consisting of an inclined trestle mounted on wheels that roll on an inclined track laid on the grade of the river bank. In renewing the cradle last year several new features were embodied. These are described by Mr. F. E. Bates, assistant Bridge Engineer of the Missouri Pacific Ry., in the Railway Age, from which the matter in this article is taken.

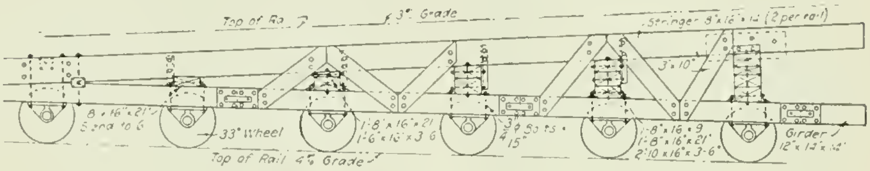


Fig. 1.—Part Elevation of the Timber Portion of Cradle.

When the Missouri Pacific cradles were renewed in 1920 and 1921, the increase in car loading and power required to handle traffic on the incline grades of from 2.5 to 4 per cent made it necessary to use heavier construction throughout and to provide additional rigidity against the heavy traction and shocks of the barge landing against the cradles. Accordingly, Coopers E-55 was used for live loading to provide for an O-6-O switch engine with 65,000 lb. on each pair of drivers, the axles being spaced 6 ft. 6 in. center to center. Both cradles are of similar construction and the description will be confined to the west cradle at West Ivory. The profile in Fig. 2 shows the grades on the cradle and the incline. The incline tracks are carried on a timber trestle with panels 10 to 12 ft. center to center and three ply 8-in. by 16-in. chords. The design and spacing of cradle supports were made to reduce the stresses in the incline trestle as much as possible. The main portion of the cradle is of timber construction with 24 ft. cast steel feather rails at the shore end and a 38-ft. hinged steel apron girder at the river end.

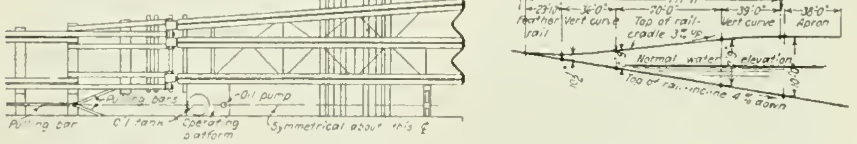


Fig. 2.—Half Plan, Elevation and Section of the Apron and Its Supports.

The details of the timber portion of the cradle are shown in Fig. 2. Special attention was given to the reduction of the unit bearing stresses, as considerable trouble was experienced in the previous cradle with bearing failures. Caps and sills 16 in. wide were used throughout. Wheels were spaced 7 ft. center to center except at the low end, where special construction was required. All wheels are standard solid cast wheels mounted on 5½ in. by 10 in. car axles. The cradle tracks are carried on two-ply 8-in. by 16-in. stringers and sawed oak cross ties with tie plates. Oak ties were used in place of pine on account of occasional derailments, and 4-in. blocks are provided for separators to supplement the notching of the outside guard timber. No drift bolts or dowels were used throughout and these were placed to permit replacing any timber members without disturbing the structure as a whole. In order to provide a certain amount of flexibility in the higher portion of the cradle to accommodate the slight changes in grade of the incline track, the 12-in. by 14-in. wheel timbers were cut and pinned together and the logitudinal bracing omitted in each second panel.

Fig. 2 also shows the special construction of apron girders and supports. To increase the car capacity of the outside or wing tracks on the barge the turnout is placed on the cradle with the frog points at the river end of the apron girders. Additional wing girders are required to support the turnouts. The rear ends of the apron girders are hinged to a heavy steel shoe supported on a six-wheel truck to distribute the loads on the incline. The pin acts only as a guide as the hole is made ⅛ in. large, and all vertical loads are carried by the rocker bearing. The pin is placed as high as possible to reduce the gap in the rails for variations of tilt of the apron girders.

The difference between light and loaded draft of the barge is 4 ft. and during loading and unloading the barge has a maximum list of approximately two feet. To provide for these variations and an allowance for inaccuracy of spotting the cradle, provision is made for a maximum vertical travel of the river end of the apron girders of 5 ft. The barge is guided to the cradle by cluster piles on the bank side and as it is very hard to maintain these clusters at the proper location provision was made for a lateral movement of two feet in either direction. Lateral movement is provided for by slotting the pin holes at the shore end in the outside girders of each set.

The apron girders are partially counterweighted from two towers. They are adjusted by means of one hydraulic oil jack at the top of each tower operated by a small hand force pump. By manipulating the two jacks separately it is possible for the operator to tilt the girders as necessary to line up with the barge as it comes in. The V's between the rails on the cradle and the corresponding ones at the front of the barge serve as guides to line the cradle and barge accurately.

The counterweight towers are carried on two steel trucks and the load is equalized on the four rails by the use of larger shims under the carrying beams over the inside wheels than over the outside wheels. The connection at the bottom of the towers was made on a slight bevel so that the towers will stand vertical when the carrying beam is deflected under load. The barge, when landed against the cradle, supports the river end of the cradle beams and relieves the counterweights and jacks of all live load.

The adjustment of the cradle to proper elevation is made by pulling or pushing the cradle up or down the incline. The steel truck frame under the apron girders is provided with heavy lateral bracing, and pulling bars, consisting of old bridge eye bars. These are connected to the two inside girders and are carried to the shore end of the cradle, where double and treble blocks and 1¼ in. steel cable are provided with anchorage to dead men for pulling the cradle up the incline. The power is furnished by switch engines. The cradles are pushed down the incline with a push pole.

Explosives Used in September.—Sales of explosives in the United States during September totaled 814,675 kegs of black blasting powder, 4,900,697 lbs. of permissibles, and 17,728,989 lbs. of other high explosives, according to manufacturers' reports to the Bureau of Mines. As compared with the preceding month of August, sales of black powder increased 35 per cent, permissibles increased 49 per cent, and other high explosives decreased 2 per cent. The increased sales of black powder and permissibles were due to greater activity in coal mining; in fact, the coal mining industry not only used more powder and permissibles, but also more dynamite and other high explosives in September than in August. Metal mining, however, as well as construction work, fell below the August record in the quantity of explosives consumed in September.

The Tie and Timber Treating Plant of the Boston Elevated Ry.

The report of the American Electric Railway Engineering Association committee on wood preservation, presented at a recent annual convention, contains an interesting description of the treating plant of the Boston Elevated Ry. The description, an abstract of which follows, was prepared by Mr. H. M. Steward, superintendent of maintenance.

The treating plant of the Boston Elevated Ry. is located in South Boston, between the coal storage field of the Boston Elevated Railway and the Boston plant of the Edison Electric Illuminating Co.

This location was selected because the land available was ample in area and a wharf on a deep-water channel was already provided.

In the track layout a connection is provided with an industrial track so that all material can be received by steam railroad if it is desired. Usually creosote oil is received in tank cars, but it can also be shipped in tank auto trucks. Provided prices are lower, ties and lumber are received by steam railroad instead of by water freight.

Due to the fact that the treating plant is in close proximity to the power station, it is possible to obtain steam via an overhead pipe line which made it unnecessary to provide a boiler in the treating plant itself. The plant was erected by Grant B. Shipley, mechanical engineer, Pittsburgh, Pa., and was completed in August, 1916. It is understood to be one of the few plants in this country that has a standard gauge track running into the cylinder.

The building which houses the treating cylinder, scales, compression, etc., is of steel frame construction on concrete foundation and is covered with corrugated iron.

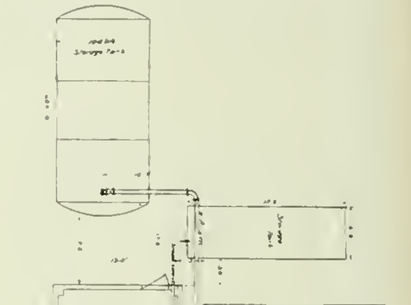
Equipment.—In addition to the tracks and building, the equipment consists of 1 creosoting cylinder, 1 working tank, 1 Howe scale, 4 storage tanks, 1 air compressor, 1 paving block machine, 1 adzing and boring machine, 1 electric service car, 1 crane car, 1 swing saw, 12 tie trucks, 4 bolster trucks and 6 wood block cages.

Creosoting Cylinder.—The creosoting cylinder is 51 ft. in length by 7 ft. 6 in. in diameter and will hold 400 ties, or approximately 12,000 ft. B. M. in one charge if loaded on 6 tie trucks, or at least 10,000 ft. B. M. of sawn lumber on 4 bolster trucks. In an 8-hour day two charges of ties can be handled and at the present time only one shift is required.

The plant, however, can be operated by three shifts or 24 hours a day if it is necessary, but if the ties and other lumber to be treated are purchased sufficiently in advance so that they can be thoroughly air seasoned, it is possible to start treating early enough in the season so that a sufficient supply of ties and other lumber will be ready for use when the track building season opens up and one shift will take care of the work during the balance of the season. This method of operating the plant is more economical than to operate on double or triple shifts and a thorough air seasoning permits of a much better treatment than would be possible with green timber.

Howe Scale.—This scale has a 10 ft. by 10 ft. platform, a registering beam with 10-lb. graduations and is of sufficient capacity to carry a tank weighing (when filled with oil) in total 158,000 lbs.

Storage Tanks.—There are 3 storage tanks 10 ft. in diameter by 20 ft. in length each having a capacity of approximately 125,000 gal., and also 1 small storage tank with a capacity of 3,300 gal., which provides for a total storage capacity of about 54,000 gal. of oil.


Plan of Cylinder House at Tie and Timber Testing Plant of Boston Elevated Ry.

Working and Pressure Tank.—The working and pressure tank is 22 ft. 6 in. in height by 9 ft. 9 in. in diameter and sets upon Howe scales previously mentioned.

Compressor.—The compressor is of the Ingersoll-Rand type and is steam driven. It has a displacement capacity of approximately 125 cu. ft. It is used for maintaining pressure and creating a vacuum.

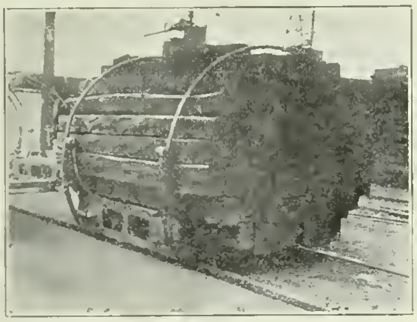
A new compressor of the two stage type, motor driven, to have a displacement capacity of approximately 240 cu. ft. will be installed shortly. After the new compressor is installed the present compressor will be put in good repair and retained for emergency.

Industrial Crane Car.—The crane car has a boom 35 ft. in length and a capacity of 15 tons. It is electrically operated and is used for handling and piling ties and lumber. The crane was added in 1921 and its use has materially reduced the cost of handling ties and other lumber. The crane is so equipped that it can be used not only in the yard but on the street if necessary.

Electric Service Car.—The car is a converted double truck passenger car equipped with 4 motors and MCB couplers, loaded with ballast, and is used for handling freight cars and also tie trucks and bolster trucks in and around the yard and in and out of the cylinder.

Greenlee Adzing and Boring Machine.—This machine is mounted on a car which can be moved around the yard and is used for adzing and boring ties.

Garland Paving Block Machine.—This machine is housed in a separate building the floor of which is about 10 ft. above the track. The plank from which the wood block is made is placed on a platform at the same height as the floor. After being cut, the blocks run by gravity through a chute into the cages which lay on a track alongside the building. When filled the cages are pushed into the treating cylinder and when the treatment is completed the cages are lifted and inverted by the crane car and the concrete dumped. In other words, the handling of the lumber and paving blocks is reduced to the minimum.


Tie Car with Load of Ties.

The machine itself is electric driven, has 8 circular saws which can be adjusted to cut the paving block to any depth required. About 12,000 paving blocks are treated per charge.

Reliance Swing Saw.—Lumber and ties frequently require cutting to proper length before treatment. It is more economical to move the cutting off saw to the work than to move the material to be cut to the machine. Therefore, a swing saw mounted on a short 4-wheel push car was provided. The saw is electrically driven, the power being secured from the trolley. It can be readily used in any part of the yard where a track exists.

Creosote Oil.—Only No. 1 creosote oil is used and each shipment is analyzed before it is unloaded into the tanks. About 150,000 gal. are used per year.

Treatment.—Ties and lumber are treated by the Rueping, empty cell process, retaining 5 lb. of oil per cubic foot, while wood paving block is treated by the full cell process, retaining 16 lb. of oil per cubic foot.

Operation of Plant.—The force employed consists of 1 engineer, 1 clerk, 1 lumber inspector, 1 foreman, 1 crane operator and from 25 to 45 laborers (mostly colored), depending on the amount of work to be done, all of whom are under the direction of the tie and timber agent.

In an average year 75,000 ties and about 1,000,000 ft. B. M. of lumber is received and treated at this plant.

As all of the work is done during one shift of 8 hours per day the capacity of the plant has never been reached. Undoubtedly twice if not three times the quantity could be treated.

No attempt has been made to treat ties or lumber commercially but in some instances piles, bridge timber, etc., have been treated for municipalities and state departments.

In addition to operating the treating plant the tie and timber agent receives and inspects all lumber used by the company whether it is to be treated or not. His office is located at the tie treating plant, where a record of the treatment of the ties and other lumber as well as other data pertaining to the operation of the plant is kept. The workmen are provided with a suitable lobby with means for heating their food and for recreation during their off time.

Fire Protection.—Four fire hydrants are located in the yard with sufficient hose to reach fire in any part of the yard. A 40-gallon Badger fire extinguisher, mounted on wheels, is also provided.

Generally ties and other lumber are received by vessels at the wharf. They are unloaded with a stevedore crew furnished by the contractor, and consequently are unloaded as rapidly as possible and piled on the wharf with little or no regard to placing them in such position or condition that they may readily be handled by the Railway company's forces and loaded on the cars to take them to the storage areas. This is one difficulty that has to be met with, and as the existing wharf is primarily for the handling of coal, when a shipment of ties and other timber is received, it is necessary to put on a sufficiently large force to clear the wharf of the ties and timber as rapidly as possible.

Three-Wire Power Distribution

The Three-Wire System Is Used by Five American Companies to Mitigate Electrolysis — What the System Is and Its Effects Described in AERA.

By GUY C. HECKER.

Special Engineer, American Electric Railway Association.

During the past few years the three-wire system of power distribution for electric railways has received some attention in this country. A brief statement of the present status of the three-wire system as used by electric railways together with an explanation of some of its advantages and disadvantages may therefore be of interest.

Without exception, the installation of the so-called three-wire system of distribution, both in this country and abroad, has been for the purpose of mitigating electrolysis. The chief advantage of the three-wire system over other methods of reducing electrolysis is its comparatively low first cost. With the three-wire system, current densities in the rails and track return circuits are greatly reduced, as are also the lengths of the return circuits, with the result that potential gradients are materially decreased. Although there are some slight reductions in the distribution losses as a result of three-wire operation, these are largely offset, if not more than counterbalanced, by the increased station losses due to the necessity of always running two sets of machines.

Installations of Three-Wire System.—At the present time the three-wire system is in operation on the following railway properties in the United States and Canada:

Pacific Electric Railway.

Omaha and Council Bluffs Street Railway.

The Milwaukee Electric Railway & Light Co.

Springfield (Massachusetts) Street Railway Co.

Winnipeg Electric Railway.

The use of the three-wire system on the properties mentioned is limited to certain districts, except in the case of the Winnipeg Electric Railway and the Springfield Street Railway Co., where this method of operation is employed on the entire system.

Foreign installations of this system are in existence on the street railways of Brisbane, Australia; Nürnberg and Dresden, Germany, and Vienna, Austria.

Forms of Three-Wire System.—The three-wire system may take two different forms which are essentially the same in principle but which differ radically as to the arrangement of the feeder layout. One of these is the so-called parallel three-wire system, which may be employed on a double track system. In this case one trolley wire is positive and the other is negative. The tracks then form the neutral, and only the difference in load on the two sides of the line returns to the power house through the rails. There may be at times heavy circulating currents flowing between cars in short sections of the track, but where cars are run on close headways such circulating currents will not flow over sufficiently great distances to set up large potential differences. The parallel system also can be used on single track lines which parallel each other on streets separated by only a few blocks. This arrangement, however, is open to the objection that frequent cross bonding becomes necessary unless the two lines are very close together, and the expense involved by reason of the cross bonding may be prohibitive.

Sectionalized System Generally Used.—The sectionalized three-wire system is undoubtedly the more practical one, and is therefore the one most generally in use. With this arrangement a line is divided into sections supplied alternately by positive and negative feeders. The tracks serve as the neutral and convey the current from the cars in one section to those in an adjoining section and return the unbalanced current to the power house. The current returning to the station, therefore, is only the unbalanced load, due to unequal loading of the various sections.

The sectionalization of the trolleys is a matter which must be given a great deal of attention. The actual arrangement in any particular instance where a two-wire system is being converted to three-wire operation will of course depend very largely upon the existing arrangement feeders. It will usually be desirable to employ these with as few changes and additions as possible, and they may easily prove to be a determining factor in the sectionalization of a given system.

The general plan of sectionalization which appears to possess the greatest merit is that of using three sections, the middle one being negative. On double track systems both trolleys in a given section should be of the same polarity due principally to the expense and difficulty of insulating between trolleys at each cross span. The plan of sectionalization used, however, should be based largely upon the results of an adequate electrolysis survey showing where the greatest troubles are being experienced from electrolysis.

Changing Feeders and Substations.—The actual physical change-over of the feeder system itself does not present any very difficult problems. The maximum voltage between the positive and negative feeders is 1200 volts. It is desirable where possible to have all positive feeders erected on one side of a street and all negative feeders on the other side. This will reduce the danger to workmen, as the potential difference between either a positive feeder or a negative feeder and ground is only 600 volts. One 1200-volt section insulator or two 600-volt section insulators in series may be used for separating the trolley sections. Standard apparatus may be used throughout in the line construction.

In general a substation can be changed from two-wire to three-wire operation at a comparatively small expense. A negative bus and double throw feeder switches for the negative feeders will be required. Also, provision should be made for revising the polarity of the negative machine or machines and for paralleling the positive and negative busses to permit two-wire operation in emergencies. If there is more than one negative machine two equalizer busses will be required, one for the positive machines and one for the negative machines. Provision should also be made for paralleling the equalizer busses during two-wire operation. Some minor changes in the instrument wiring will be required, and it may be desirable to install double reading ammeters on all of the negative machines and negative feeders. Due to the fact that the series connection between the two machines is permanently grounded voltage strains imposed on the machines will be no greater than those imposed under two-wire operation. Standard apparatus may be used throughout in changing over substations from two-wire to three-wire operation.

Relief from Electrolysis Trouble.—In the installations previously referred to it is claimed that great relief from electrolysis troubles has been experienced. It is contended by those companies that the three-wire system has afforded the desired relief at a lower first cost than any of the other systems commonly employed for electrolysis mitigation. A reduction in the loss in the negative circuit is secured, but because of the increased station losses this saving is of very doubtful value.

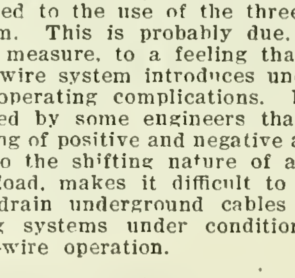
The three-wire system is necessarily more complicated than the two-wire system. In order to secure proper and economical loading of generators or converting equipment the sectionalization of the trolleys must be very carefully worked out. It is difficult to secure the advantages of parallel operation of stations to the extent possible with the two-wire system. In a station containing only two machines it is probable that the three-wire operation will prove economical only during the peak load periods. When changing temporarily from three-wire to two-wire operation, in an emergency, there is always the possibility of paralleling feeders with those of opposite polarity from another station with possible damage to the equipment and perhaps considerable delay to the service.

Other Mitigators of Electrolysis.—Other methods commonly used to relieve electrolysis conditions are the drainage system, the insulated negative system, and the use of negative boosters. A recent competitor in the field of electrolysis mitigation is the automatic sub-station. The automatic sub-station increases the number of feeding points which can economically be employed with the result that current densities in the return circuits and lengths of return circuits are reduced, thus effecting improvement in electrolysis conditions. Although automatic sub-stations are being installed primarily for economic reasons, improved electrolysis conditions will generally follow their installation.

As previously stated, the three-wire system thus far has been adopted purely as an electrolysis prevention measure. It does not seem advisable to recommend it generally for this purpose, except where a thorough study of actual conditions and a careful investigation of the results of the various methods of obtaining relief, show it to be the most economical plan. Most railway men appear to be opposed to the use of the three-wire system. This is probably due, in a large measure, to a feeling that the three-wire system introduces undesirable operating complications. It is claimed by some engineers that the shifting of positive and negative areas, due to the shifting nature of a railway load, makes it difficult to properly drain underground cables and piping systems under conditions of three-wire operation.

"Home Made" Grass Cutter for Interurban Line

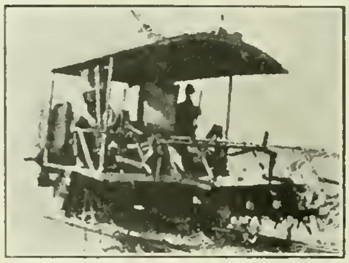
An efficient grass cutter built at the shops of the Texas Electric Ry. Co. is described in Electric Traction. This cutter takes care of the entire line of 249 miles of single track at an operating cost of 68 ct. per track mile.



Swath Cut Along Track by Cutter.

The machine is mounted on a heavy 4-wheeled truck, with canopy top and side curtains for the protection of the crew and motors. The apparatus for cutting weeds and grass consists of a steel 2 15/16 in. shaft, 10 ft. 6 in. long, having a series of wire cables, 22 in. long, spaced 3 in. apart, on the shaft, which cut and tear the grass and weeds when the shaft is revolved. The shaft is belted to a 15-h. p. motor, and run at a speed of 1,000 r. p. m. and is raised and lowered by a system of levers, so as to clear cattle guards and other obstructions along the track.

The car is propelled by a 6-cylinder gasoline motor which was taken from a wrecked automobile. The motor is mounted over the rear wheels of the truck and is connected to same by means of a chain drive.



Close-up of Grass Cutter.

When cutting heavy growths of grass and weeds, the car can be run at a speed of 4 miles per hour, but it can be operated, with the cutter up, at a speed of 40 miles per hour with safety, enabling it to get out of the way of regular trains without a great loss of time. Two men are required to operate the machine and from 15 to 24 miles of track can be cleaned per day, depending upon the extent of the growth and the amount of traffic on the line.

B. & O. R. R. to Construct New Grain Elevator at Locust Point.—The Baltimore & Ohio R. R. has let a contract to the John S. Metcalf Co. of Chicago, specialists in grain elevator construction, for the preparation of plans and specifications for the new grain elevator facilities at Locust Point, Baltimore, Md., in replacement of the two old elevators destroyed by fire July 2nd last. The tentative plans which have been worked out by the Baltimore & Ohio officials, on which the grain elevator architects will now prepare drawings and specifications, call for a steel concrete elevator of the most modern type. The storage bins with capacity of 3,000,000 bus., will be so arranged that they can be readily increased to 8,000,000 bus. The plans include complete facilities for drying and cleaning grain, also provisions for unloading grain from boats. The latest approved safeguards against dust explosion will be used. The elevator will be constructed on the water's edge adjacent to piers, with galleries and belt conveyors reaching eight berths, four of which will be located on an exclusive grain loading pier, to be constructed for that purpose, the other four on a two-story merchandise pier already in use. Provision will be made so that the gallery system can be extended to other piers in the future. It is expected that the architects will have the detail plans in shape for submission to the railroad engineers within three months, after which invitations for bids on the construction work will be issued. All the work in connection with these improvements will be under the direction of Mr. H. A. Lane, Chief Engineer of the Baltimore & Ohio R. R. Company, assisted by his Engineer of Buildings, Mr. L. P. Kimball, who will have immediate supervision, having associated with him Mr. L. A. Stinson, of Chicago, as consulting engineer.

Buildings and Structural Issue

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(c) Streets
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Sanity in Standardization

The standardization of materials, machines and methods is logically a subject for careful study and development, but the most conspicuous discussions of it have come from the extremists both pro and con. According to the "pros," progress is largely a matter of quantity production: the more things we can make and use or make and sell, the greater our progress. Wherefore standardization to the limit is their motto. The extremists commend original art in every production. For them the copying of beauty and the use of standard structures, point to stagnation of art and invention, and already constitute a menace to progress. Thus both sides, if we read them aright, recognize progress as an ultimate aim of man, but differ as to what constitutes it. The difference, we suspect, is primarily one of thoughtlessness; for though progress is too complex an idea to be easy of complete definition or full analysis, it undoubtedly embraces, when applied to a people or a nation, both the improvement of the general welfare and the continuing development of every art to the production of higher forms and added accomplishments. Progress lacking either of these elements would be incomplete; and so we have at once a justification of standardization because of the good it brings to the many, and a warning against over-standardization because unquestionably new accomplishments and the development of art may be impeded thereby.

Personally we have no fear that either standardization or the lack of it will interfere with America's progress. Commercial interests and a widely distributed buying power make a vast amount of standardization inevitable, and against this combination the hyper-sensitive artist but wastes his effort. At the same time the grossest commercialism finds profits in invention and improvement; and may, we think, be relied upon to support initiative even while it produces on a quantity basis. Couple with this the individual inventive instinct—never completely lost even in such backward countries as India and China, and nowhere more prominent than in America—and you have a combination not to be smothered by any quantity of standards with which it may be surrounded.

To consider a case in the field of architecture take the old-fashioned row of operatives' cottages all exactly alike. It grossly offended the finer sensibilities, and had naught but commercial economy to recommend it. Happily it is now in disfavor, and is being succeeded by groups of attractive dwellings similar in size and cost but differing substantially in appearance and sometimes even in type. Few deny the desirability of making the buildings different, but how far should we make the details to differ? A very rich concern might build for its operatives, houses, each having all the wealth of original detail that the architect's ideals suggest, but it would be a rare case indeed in which other wants could be supplied on a corresponding scale. Standard mouldings, cornices and other materials—stock stuff, if you please—is the practical thing to use in such instances as it is for the average small home that is independently built. It is fine and proper for the rich to seek originality in such matters, but for the poor and the moderately circumstanced it is impracticable.

We don't know just how it is proposed to stop standardization, but whatever the proposals, we can see no possibility of their success. We believe that improvements in the general character of our buildings will go right ahead as it has done in the past with a joint use of both standard and original designs of material, and that although the ardor of the extremists is interesting and perhaps even beneficial, real progress is not dependent upon it.

The Landis Award Progresses

Last week the Building Trades Council of Chicago elected Edward Ryan president and went on record as accepting the Landis Award governing wages, hours and practices. While the acceptance does not indicate a complete and final settlement of labor difficulties in Chicago's building industry, it is a good omen and decidedly a step in the right direction. In spite of the regrettable refusal of the carpenters' union to enter the arbitration proceedings and the vicious repudiation of their arbitration agreement by some of the other unions, substantial progress has been made; and this latest action indicates an increased appreciation of the justice, fairness, and beneficial character of Judge Landis' decisions in this matter.

It is desirable that the unions should be working under the award. There is no question that in general union workmanship is of better quality than non-union; and we believe that union members will find themselves much better off under the award, even at somewhat lowered hourly rates, than outside it. What will be the difficulties of the agreement repudiators in getting in we cannot say.

The election of Mr. Ryan, no less than the Council's action on the award, is a subject for congratulation. Union leadership rather than union membership has been at fault in Chicago as in many other places; and whether or not Mr. Mader, who is succeeded by Mr. Ryan, is guilty of all the crimes with which he has been charged, his leadership was of an undesirable type. He was too closely associated with sluggers and other criminals to be worthy the confidence either of the public or the membership of the organization which he headed. Mr. Ryan seeks the welfare of the unions, but he does not depend upon violence to secure it.

Winter Erection of Steel Shed Under Canvas

By completely encasing the entire pier under 50,000 sq. ft. of canvas the contractors for the erection of a 2-story steel shed 70 ft. by 550 ft. on Pier 4, South, in the Delaware River at Philadelphia, were able to continue work during the severest weather of last winter. We are indebted to Successful Methods for the following particulars.

The framework for supporting the canvas consisted of 3 by 4 spreaders or struts placed against the steel columns and 3 by 6 uprights wired to the columns. The canvas was made fast to the 3 by 6, by means of canvas ties on 4-ft. centers, and horizontally by means of gauntlet holes on 2-ft. centers. Twenty-one-ounce white duck was used and the resulting decrease in the lighting of the interior was surprisingly small. The erecting of the framework and the hanging of the canvas was done by 20 carpenters and 10 laborers working 2 full weeks of 8-hour days.

With the exception of the offset in the roof in the third bay, the 2-in. roof sheathing was placed in advance, the canvas being fixed to the steel column over 1-in. boards. Great care had to be taken in attaching the canvas so as not to interfere with the roofers or the men placing the eaves, flashing, gutter and downspouts.

For the bottom support of the framework, the ground log, which is a 10-in. by 12-in. timber 4 ft. from the columns and running the entire length of the pier, proved ideal. The space was sufficient and the masons had no trouble in doing their work. The bays being 20 ft. and the height 40 ft., the 20-ft. by 20-ft. sections of canvas were exactly what were needed. Both sides, as well as the river end, were covered in a similar manner. On the outside, nailing strips nailed to the ledgers and uprights at the columns were used.

Inside this canvas inclosure, a steam heating plant was set up. At each column (columns on 20-ft. centers) radiators were placed betwen the canvas. and the wall. These radiators, having 100 ft. radiation, were fed by one central boiler of 80 hp. capacity. By means of this system, it was possible to maintain a temperature within the canvas of 35° higher than that on the outside during all kinds of weather.

From Jan. 25, the time when the canvas inclosure and heating plant were completed and put in operation, not a single day was lost and a working force of over 100 men was able to work without interruption through out.

The J. S. Rogers Co., Philadelphia, was the contractor.

Relation of Zoning to City Development

Address Before Joint Meeting of Engineers' Club of Philadelphia, Philadelphia Sections of Am. Soc. C. E., Am. Soc. M. E.

By B. ANTRIM HALDEMAN.

Zoning has been called a little brother of city planning. Perhaps it is not quite right to call it "the little brother" because since we began to talk zoning, less than ten years ago, it has grown so rapidly in popularity and has made so much progress I am not certain but that it is bigger than its older brother.

We have been talking city planning for about 30 years and it has come to be pretty well acknowledged as a necessary function of municipal administration, but during these 30 years it has not made more rapid progress than zoning has in less than 10 years. It is true that as far back as 1892 Boston passed an ordinance limiting the height of all buildings in that city. It is also true that in 1904 Baltimore passed an ordinance limiting the height of buildings in the vicinity of Mount Vernon Place and Washington Place near the Washington monument. It is also true that Los Angeles, in 1909, passed an ordinance declaring that city a residential zone, with certain exceptions. It is also true that all of those ordinances were tested through the local courts, through the State courts, and through the Supreme Court of the United States, and all were sustained by the latter court. The decisions in the Welsh vs. Swazey case in Boston and the Hadacheck case in Los Angeles, together with other more recent favorable decisions by the courts, makes us feel safe in going ahead with zoning plans so long as we follow the trail blazed by the Supreme Court of the United States.

Introduction of Zoning in United States.—Notwithstanding those early ordinances, it was only about 1912 that we began to talk seriously about zoning in the United States. In that year the National Conference on City Planning discussed the subject at its meeting in Boston, and I am frank to say that we were a bit uncertain as to how the idea might be received in this country. We thought it might be accepted in the newer, more progressive and more aggressively ambitious cities but that the larger and older cities might be somewhat reluctant to undertake the establishment of zoning regulations. I think we all agreed that if it ever did become an active and popular movement New York would be the very last city to accept it. Contrary to our expectation, New York City was the first in the country to enact and enforce a complete code regulating the height and use of buildings and the areas they might occupy. The enactment of that code on July 25, 1916, marked the real beginning of zoning in the United States.

Acceptance of Zoning.—Since that time 20 states have enacted legislation authorizing the zoning of cities and in a number of other states cities are granted such a degree of home rule by their charters that it is not necessary for them to obtain legislative permission. Twenty-seven cities have enacted complete codes regulating height, use and area, and 58 cities are preparing such complete codes. Nineteen cities have enacted partial codes, and 35 cities are preparing such codes.

This means that 139 cities in the United States have officially accepted zoning as good public policy; a record for any civic movement in this country; a record for any movement ever started which had for its aim and purpose the better protection and finer development of American cities.

Order—Important Object of Zoning.—It has been customary for the advocates of zoning to give special emphasis to its merits as an agency for stabilizing values and while that is very important its merits as an agency for producing and maintaining order appear to have been neglected. The orderly development of cities would seem to be a very proper and important object of zoning since order is admittedly necessary to the public welfare These are all vital to proper city development but order appears to have been stressed very little in support of zoning.

While I recall visiting some architects' offices that were anything but orderly, the builder who does not follow the orderly program laid out by the architect is very likely to find himself in serious difficulties. The realtor is certainly much gratified and probably feels that he can safely boost the price a bit when he takes a prospect out to show him a property and finds that the neighborhood is fine and orderly with surroundings admirably adapted for the particular activity in which his client is interested. Therefore, one of the important things the advocates of zoning are asking is that the opportunity be given for bringing order out of the chaos of the present methods of city building and that an opportunity be given to apply to city building at least a reasonable degree of the orderliness that every successful person recognizes as necessary to success.

Why is it necessary that factories, office buildings, stores and dwellings should occupy the same block any more than it is necessary for a department store to sell diamonds, gum boots and sledge hammers over the same counter. Neither a department store nor any other business could be successfully and profitably conducted in the haphazard manner characteristic of the growth of our cities. Every one of you who has an office or conducts a business enterprise of any kind likes and probably insists upon order in that office and business, and you like to be surrounded by things which make your work pleasant, congenial and inspiring. You also like as much of beauty in your surroundings as is consistent and reasonable with your business. Then why not treat your city in the same manner you treat your office and your business.

Reason for Popularity of Zoning.—One reason for the popularity of zoning is that it offers a maximum of protection and benefit with a minimum of expense and effort. It can perhaps be predicted with confidence that before the end of another decade a zoning code and districting plan will be considered just as necessary to a safe and well ordered city as a building code. Great constructive movements are usually of slow growth but the progress of zoning has been phenomenal. Another reason for the popularity of zoning is that our standards of living are quite different and much higher than they were 25 years ago. Our standards of education, culture and refinement have risen and we have made rapid progress in science and art. We live differently, travel differently, transact our business differently. The style of architecture has improved. We want more elbow room, more light, more air, and more comfort in our homes and places of business. Consider the modern industrial building. You have all noticed how glass has taken the place of solid walls in it and you seldom see one erected to the heights they were 25 years ago. Go up in the northeastern industrial district and compare the industrial buildings of 25 years ago with those of today and observe the difference, not only in buildings but in their surroundings, and you will see zoning done by the employer of labor who realizes the importance of light and air in conducting his business. It is a matter of economy and efficiency with him. He realizes that his labor is more loyal and more efficient if it works among better surroundings and with better light and air. The same thing can not be said of the modern, many-storied office building. It is not built for light or air, or for elbow room or comfort for its occupants, but for rents and revenues for its owners. Most modern office buildings must be artificially lighted even on sunny days and they are very poorly ventilated. A single high building may have splendid circulation of air and may even be well lighted from outside until other high buildings surround it and cut off both light and air.

Necessity for a Zoning Code.—The most familiar and oft repeated protest against zoning is that it interferes with the right of the individual to do as he pleases with his own property. That is a right which has probably never been fully possessed by any civilized individual in any age. Even absolute monarchs have always had to recognize certain customs and laws of civilization. The majority of the people responsible for the development of our cities probably do the best they can under the circumstances and have a proper conception of their civic duties and their obligations to the public but there is always a small percentage in every profession and business who will persistently ignore the rights of others in order that they may better serve their own selfish purposes. It is that small percentage who persistently and consistently ignore the rights of others whose actions and conduct must be regulated by law. If all obeyed the golden rule a zoning code would probably not be necessary, but, as matters stand, such a code is necessary to check the mischievous operations of a comparatively small number of people who are responsible for the iniquitous practices for which there is now no effective preventive.

Without a zoning code to correct present and growing evils we may drift further and further into the much criticised practice of government by injunction. That possibility is suggested by the manner in which the courts of many states have been deciding cases involving the use of private property. Most of you are familiar with some of the recent garage cases. There have been several in Philadelphia that are epochmaking. One in West Philadelphia where the property had been purchased and valuable buildings torn down when an injunction was obtained and the owner was restrained from erecting a garage on the property. In another case, in almost the same neighborhood, the owner was prohibited from using a building for garage purposes after it had been erected. There have been two quite recent cases in the Dauphin County Court. In one, a public garage which had been in operation for a considerable time was ordered to close; in another, in a town of only a few hundred inhabitants, a public garage was ordered to close at 9:30 p. m., and to remain closed on Sunday.

Attitude of Courts Toward Zoning.—The courts are doing the same thing to apartment houses and to some other kinds of use in the Middle West and West. We have been reluctant in the East in preparing our zoning codes to go as far as some of the courts, and particularly the Supreme Court of the United States, have indicated we may safely go, on account of the more conservative opinions that prevail here. Some of the most important decisions in support of zoning have been handed down in Western courts. The Supreme Court of Minnesota decided that a city council exceeded its power in enacting an ordinance to exclude apartment houses from what was declared a single-family house district, but the case was reopened in less than three months and the court reversed itself.

These decisions indicate the attitude of the courts toward zoning and while there has been criticism of them by parties opposed to zoning they will continue to be the guide, particularly those rendered by the Supreme Court of the United States which is the final interpreter of police power law. It would seem far better policy to have regulations definitely established by ordinance than to have the courts crowded with such cases and building operations subject to the constant menace of injunctions, since every neighborhood that objects to a factory or an apartment house or a business or a garage may take the case to court with a more than even chance of having the operation stopped if evidence can be produced that it is a menace to the welfare of the neighborhood. This is being done so successfully in many parts of the country that such cases are certain to increase in number unless districting regulations are established.

Zoning Code Similar to Building Code.—A zoning code is very similar to a building code except that under the former a city may be divided into districts with different regulations for each district while the latter applies uniformly throughout a city. Building codes might be made to operate very much the same as zoning codes are intended to do. A building law was drafted by a committee of the Pennsylvania legislature several years ago which went almost as far as a zoning code is intended to in regulating buildings except that it did not contemplate establishing use districts.

Zoning Will Protect Values.—I do not think a properly drawn zoning code, and it must be properly drawn or it will not stand the test of the courts, will destroy one dollar of actual intrinsic value that any property now possesses. There may be cases here and there where the limitation of the height of buildings will interfere with speculative values, and there may be cases where the accumulation of the unearned increment may be somewhat retarded, but so long as we cannot tax the unearned increment or the speculative value for local purposes to cut some of them out might be a public benefit. No one needs to fear losing anything they actually possess, but, on the other hand, zoning will go very far to protect values which already exist.

We have recently gone through an intensive "own your own home" campaign, and thousands of people all over the country have been practically forced, in many cases against their wish and against their will and against their financial ability, to assume the responsibility of purchasing and paying for a home at a time when property was at the absolute peak of its value with the almost certain probability that there would be a decline rather than stability or a further increase of value. Unless those owners are protected, thousands of our best citizens, those who make up our great working army, who have put all their savings into a home and have mortgaged their future, may lose all they have saved during a lifetime of honest toil. I do not think anyone wants that fate to overtake the wage earners of this country, but they are threatened with it so long as any kind of an offensive business or industry is permitted to be set down in their neighborhood. It is a duty of the real estate men and others who promoted that campaign to support any measure that will help to protect the interests of those people. So far as zoning may stabilize value it ought to be exercised to stabilize those values, even though it may destroy some speculative values and prevent the pyramiding of the unearned increment elsewhere.

Piece-Meal Zoning Dangerous.—Piece-meal zoning such as has been suggested by the Council of Philadelphia is dangerous. The cities I have referred to as having partial code have regulated the entire city for either use, height or area. Boston, for instance, has only height regulations. The entire city is districted and regulated for height, but not for use or area. That is not dangerous. The kind of piece-meal zoning that is dangerous is to leave some district without regulation where other parts of the city are regulated for either use, height or area. Suppose you zone all Philadelphia except one or two districts. Those unregulated districts become the dumping ground for all the nuisances that are prohibited in other parts of the city and the courts are likely to say the code discriminates unfairly against the unregulated districts in that it provides no regulations whatever for them and is therefore not a proper exercise of police power.

Some Tile Problems of the Architect

Abstract of An Address Before the Convention of the Tile and Mantel Contractors' Association

By D. KNICKERBOCKER BOYD.
Architect, Philadelphia, Pa.

Let us begin by clearing up the mystery which has surrounded the grading of tile by having it thoroughly understood that the three grades, in white glazed wall tiles, are not the result of any intent of the manufacturer to produce different qualities. It is surprising how many architects and others do not realize that tiles are not manufactured in predetermined grades and qualities, but that the grades result from the selection made in the product which the manufacturer has tried with all the materials and forces at his command so to make and burn as to produce but one grade, the highest quality obtainable.

Architects and their clients, and in fact all users of tile, must be informed that, due to limitations and firing conditions, certain variations in shades, sizes, etc., are inherent in the manufacture of clay products.

The recent adoption by the manufacturers of the classification "selected," "standard," and "commercial" will go a long way to help us all to secure the tiles intended. In the past even a person of limited means has objected to the term "second quality," when as a matter of fact the tiles heretofore designated by that unfortunate name were most suitable for him. On the other hand, it would be equally unfortunate to specify for such a building first quality tiles only, free from all blemishes and defects, yet such has been a very general practice due to lack of knowledge.

I am sure, too, that almost all architects, if they knew of the great amount of time which is spent on the mere "shading" of glazed wall tiles, would feel as those do to whom I have made the fact known, that every encouragement should be given to the use of "run of kiln" tiles, so far as color is concerned.

Fewer Names Would Simplify Architect's Problem.—The time and effort now spent on shading could thus be given to more creative effort—an end most devoutly to be sought. And in the opinion of many of us the result would be much more satisfactory from the point of appearance alone, removing at the same time much of the mechanical effect obtained when all tiles are uniformly white.

It is very important, it seems to me, that some simplification of titles and names be considered to make them more significant of characteristics, colors, and proper uses. There are now too many names for kinds. With fewer basic names, no matter how many trade names might be given by manufacturers, this part of the architect's problem would be solved.

Take for instance vitreous and semi-vitreous as words to conjure with. In most instances the same kind of tile is either vitreous or semi-vitreous, but none seem to know the relative difference in hardness, absorption, or reasonable appropriateness for exposure or use as between them; and few know that the only reason why a semi-vitreous tile is not vitreous is that the nature of the materials used to produce certain colors (red, brown, chocolate, and black) is such that it is impossible to burn them to the same degree of hardness without destroying not only the color but the body of the tile as well. It is very simple once it is known.

But take the same vitreous and semi-vitreous and consider them from the standpoint of size, and it appears that if the size is smaller than 1¼ in. the tiles are known as ceramic mosaic. Between that size and 3 in. the same kind of tile is known as floor tile. Fom that size up to 6 in. if the tiles are vitreous they are known as flint tile, but if semi-vitreous they are known as floor tile. And all the while we have with us the quarry tile in sizes both under and over 6 in., and all semi-vitreous.

Lack of Complete Data Has Handicapped Architects.—Surely it is up to the industry and the tile contractor to make all simplifications possible, and to put out this information for the benefit of architects and users. Through co-operation we will likely accomplish great results in that direction, but let me say that in the meantime it is my belief that these complications and lack of information have deprived architects of the opportunity to take fullest advantage of tile, through the erroneous impression that but three general classes of tile were available and only the first named two in "regular" colors and but few standard sizes, namely:

White tiles for bathrooms, toilet rooms, lunch rooms, barber shops, drug stores, etc., in bright and dull glazes and not in small sizes, for walls; unglazed or vitreous tiles, not in large sizes, for floors—and the latter, when not white, furnished in fixed atrocious combinations of pattern and color;

Quarry tiles and light or plain colored unglazed tiles for floors and

Faience or decorative tiles, in which class were thought to be included all those attractive colors and units to be seen in hotels, libraries, clubs, fine residences, and similar buildings—the belief in most cases prevailing that the tiles in each of such installations were especially made to fit each pattern or design and consequently involved considerable cost, and hence were to be avoided for ordinary usage.

Architects are designers, but before they can design they must have complete data as to the materials with which they are to work out the design should know the source, production, and characteristics of tile, and colors and sizes should be readily obtainable.

Structural Steel Sales in October

October sales of fabricated structural steel amounted to 54.9 per cent of shop capacity, compared with 61.6 per cent in September. Reports to U. S. Bureau of Census received from 140 identical firms from April through October, with a shop capacity of 221,790 tons per month, show the following actual tonnages booked each month and the percentage of shop capacity represented by these bookings. A revision of these capacities in accordance with a uniform standard is now being undertaken by the Bureau of the Census but the results are not yet complete.

	Tonnage booked.	Per cent of capacity.*
April	191,805	86.5
May	172,260	77.7
June	153,278	69.1
July	141,907	64.0
August	143,515	64.7
September	136,587	61.6
October	†121,763	54.9

*The inclusion of additional firms this month has made slight revisions in the per cent of capacity reported previously.

†October sales prorated for one firm which failed to report and represented about 1 per cent of the total.

The Preparation and Properties of Pure Iron Alloys

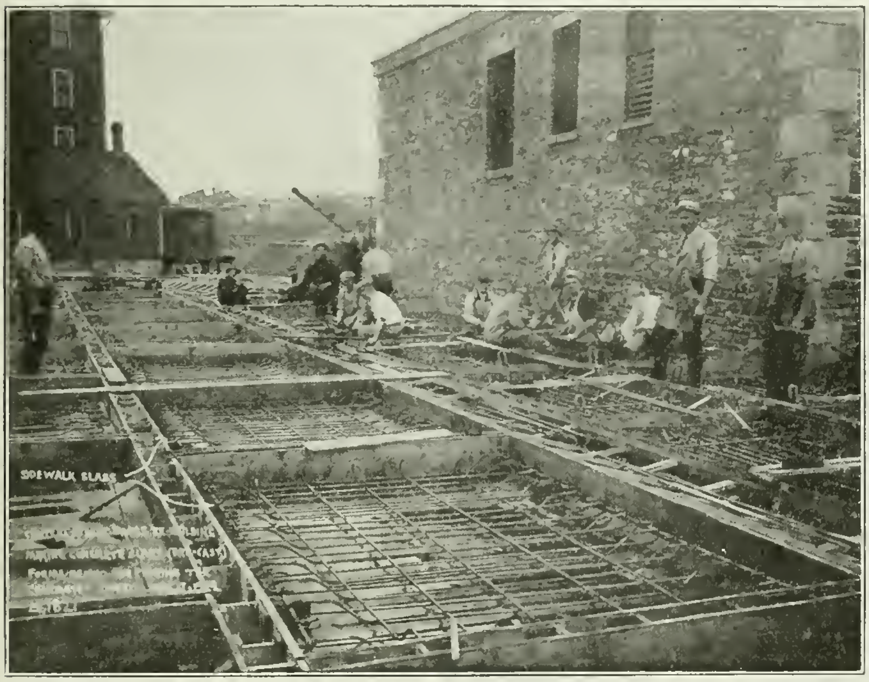
Scientific Paper No. 453 of the U. S. Bureau of Standards entitled, "The Preparation and Properties of Pure Iron Alloys," deals with fundamental principles involved in the manufacture of steel products. To protect life and property, it is necessary that the architect and engineer know the kind of steel which should be specified for each use. To know what composition a steel should have in order to withstand a certain amount of strain or to meet necessary requirements, the effects on the steel of each of its constituents must be known. The general effects of each of these constituents have long been familiar, but technical difficulties have hindered really thorough studies of the specific and exact effects of each of the elements. Very pure iron is difficult to prepare, and it is even more difficult to add a controlled amount of some one constituent of steel to pure iron without some contamination. In this investigation iron of practically 100 per cent purity was prepared by an electrical method similar to the method of silver plating in which the metal is deposited from a solution by the passage of an electric current. The iron is plated out leaving the impurities behind. This iron was then melted in a vacuum to exclude the effects of gases which would be taken up from the air if melted in contact with it. The heating was done electrically, and the containing crucibles were made of chemically pure magnesium oxide. Extensive series of alloys were made by remelting this iron in this manner and adding carbon and manganese. Compositions were varied by small amounts so as to include the entire range of compositions found in ordinary steels. Specimens from these ingots were tested and results compared so as to bring out the effects of each element. This paper will be ready in a short time and may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 ct. per copy.

Pre-Cast Concrete Slab Bridge Construction

Methods Used in Reconstructing Bridge at Central Street, Lowell, Mass.—Described in Paper Presented Oct. 18 Before Boston Society of Civil Engineers.

By S. S. KENT,
Assistant Engineer, Locks and Canals, Lowell, Mass.

In so far as we know, there is but one water power company in Massachusetts that is responsible for the maintenance of bridges on the public highways. It is the great misfortune of the proprietors of the locks and canals on the Merrimack River at Lowell to be that one company. The charter which was granted the proprietors by the General Court in 1792, for the purpose of promoting navigation, placed certain obligations for the maintenance of bridges over the Pawtucket Canal on the navigation company. About 1821, the rights of the proprietors of the locks and canals were purchased by the Merrimack Mfg. Co., additional canals were dug, other manufacturing companies were interested to take part in the enterprise, and the development of water power used mostly for textile manufacturing became a more and more important use of the system, while with the coming of the railroads the use for navigation gradually died out. But the bridges are still with us.



Constructing Precast Concrete Slabs at Yard of R. E. Runnels Co.—View Shows Forms Ready for Pouring Concrete.

Among them is the Central Street bridge over the Lower Pawtucket Canal. At this point the canal is about 80 ft. wide with a pier in the center which divides the canal into two skew spans each from 40 to 45 ft. in length measured in the direction of the roadway. The average width of the street is about 65 ft., nearly 28 ft. of which is taken up by the two sidewalks. Of the 37 ft. between the curbs, the central 15 ft. or so are occupied by two car tracks. The first bridge over the canal at this point was built some time between 1792 and 1796, at which latter date the canal was opened. The bridge was rebuilt in 1836, again in 1850 and still again in 1883. It was the bridge built in 1883 that was replaced this last summer. That bridge was built of queen post trussed stringers spaced about three feet on centers. Each truss consisted of two 7 by 14 in. stringers with a 1½ in. diameter wrought iron truss rod in between.

The Old Bridge.—The construction was described as follows by Mr. James B. Francis, under whose direction the bridge was built.

"The stringers are of southern pine, the under planking 2½ in. spruce, planed to a thickness of 2⅜ in., matched and jointed and laid as tight as practicable, and strongly spiked to the stringers covered with coal tar of the kind used for concrete sidewalks put on hot and while soft, the top plank of 3 in. Canada pine jointed but not planed was put on and spiked to the plank under it, the spikes not going through.

"The surface of the roadway and sidewalks is of coal tar concrete 3½ in. thick put on hot, costing $1 per square yard. The part of the same between the rails of the horse railroad track was paid for by the Horse Railroad Co.

"The work was all done without interrupting the ordinary travel or the use of the horse railroad. The pier with the exception of the capping was completed before the roadway or sidewalks were disturbed.

"The roadway was divided into three divisions, the middle division including the horse railroad, was first taken up and rebuilt, the railroad having been first moved to the westerly side and the ordinary travel provided for on both the side divisions. When the middle division was completed, the ordinary travel was provided for on it and the westerly side division and the other side division taken up and rebuilt. When this was completed the remaining division was taken up and rebuilt."

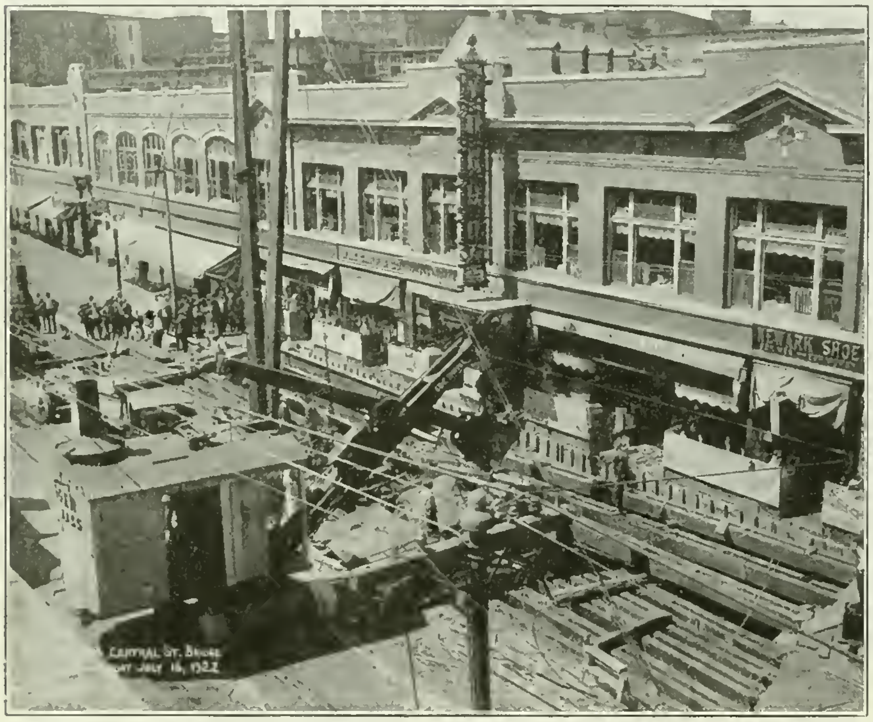
It will thus be seen that a precedent was established for the reconstruction of the bridge without undue inconvenience to the public.

The construction of the 1883 bridge was begun on July 22 and completed on Oct. 12. In 1900 the trussed stringers under the street railway tracks were replaced, and in 1907 strengthened again. In 1912 they were replaced by four steel girders which were not disturbed during the reconstruction of the bridge last summer. Outside of the section occupied by the

View of Reconstruction Operations Taken July 16 After Half of the Deck Over the Southernly Span Had Been Removed.

street railway tracks, the bridge has required no repairs since 1883 excepting for the wearing surface which in recent years had required extensive patching almost annually. When taken out the main timbers were found perfectly sound, as was also most of the planking outside of those parts near the street railway section and the curbs. The cause of renewing the bridge was the poor condition of the wearing surface and the excessive vibration of the entire bridge due to modern heavy loads.

Problems of Reconstruction.—The density of traffic on Central St. made the reconstruction of the bridge something of a problem. The bridge is within 2½ blocks of Merrimack Square, which is the traffic center of Lowell, and it is hardly an exaggeration to say that virtually one-half of the city of Lowell is reached by way of Central St. There is no parallel street in the near vicinity over which traffic could be diverted. Electric cars pass over the Central St. bridge at the average rate of 70 per hour from 5:30 in the morning until 11:30 at night. To close even one-half of the bridge for any length of time would cause serious inconvenience to the public.



Steam Shovel Removing Deck of Old Bridge.

The situation was further complicated by the fact that there have been business blocks put up over the canal on both sides of the bridge, with five store entrances to be kept open on the upstream side of the bridge and six entrances, including the Strand theater, on the downstream side. The Strand is Lowell's largest moving picture theater. The platforms over the canal on which these buildings are located are owned and leased by locks and canals, and although the leases contain clauses reserving the right to rebuild the bridge, yet a moral if not legal obligation was felt to cause the minimum of inconvenience.

The situation was somewhat complicated from the structural side by the pipes and conduits which cross over the canal under the bridge. On the upstream side is a 16-in. city water main and a 12-in. gas pipe, both supported by independent trusses, and also a conduit containing a cable supplying a series current to the "White Way" lights, with one of the lamp posts located on the bridge. This conduit was hung from the bridge, as are also a nest of electric light conduits and a group of telephone cables which cross the canal on the downstream side.

Furthermore, it is a skew bridge in the superlative degree. The lines of the abutments and the center pier all form angles with each other, and the same is true of the building lines and the curbs. There is no such thing as a right angle in the bridge.

It will thus be seen that the conditions called for a type of bridge which could be erected in the minimum of time and could be thrown open to traffic as soon as completed. Precast concrete slabs were suggested by Mr. W. H. Durfee and seemed to meet these requirements best and bids on this type of construction were called for by Mr. Arthur T. Safford, chief engineer of locks and canals.

Design of New Bridge.—The design submitted by the New England Structural Co. made under the direction of their Chief Engineer, Mr. E. N. Pike, was accepted. The plan as finally carried out was as follows:

Three 30 in. Bethlehem I-beams support the roadway on each side of the street railway tracks, with a 28 in. and 26 in. Bethlehem beam under each sidewalk. The roadway girde are braced at 11 ft. intervals with 10 in. I-beams, the tops of which are set flush with the tops of the main girders and with them form a quadrilateral of steel to support the precast slabs. The slabs were designed to average about 11 ft. in length by 5 to 6 ft. in width and 7 in. to 12 in. in thickness. This gave a weight of from 4 to 5 tons for each slab. The bridge is on a slight grade. This and also the crown of the bridge were taken care of by setting the tops of the I-beams horizontal and varying the thickness of the slabs. The slabs were designed for the standard 20-ton truck as specified by the State Department of Public Works. Five-eighths inch round reinforcing rods were used in both directions with every alternate rod bent up at the ends. The edges of the slabs were recessed ½ in. for a width of 5 in. to 10 in., so as to let them fit down into the steel work. Kreolite wood blocks were laid on top of the slabs to form the wearing surface. It was at one time suggested that perhaps the tops of the slabs themselves could be used as the roadway surface, but the idea was abandoned for fear that the slabs would chip on the edges and that patching would prove difficult. The precast slabs were made for all of the roadway outside of the street railway area and for one-half of each sidewalk. The outer half of the sidewalks next to the building lines was poured in place. Base plates to carry the main girders were set in the abutments and the center pier previous to the reconstruction. It was proposed to rebuild one-half of the bridge between Saturday night and Monday morning, excepting for that half of the sidewalk to be poured in place, and repeating with the other half of the bridge on the following week end.

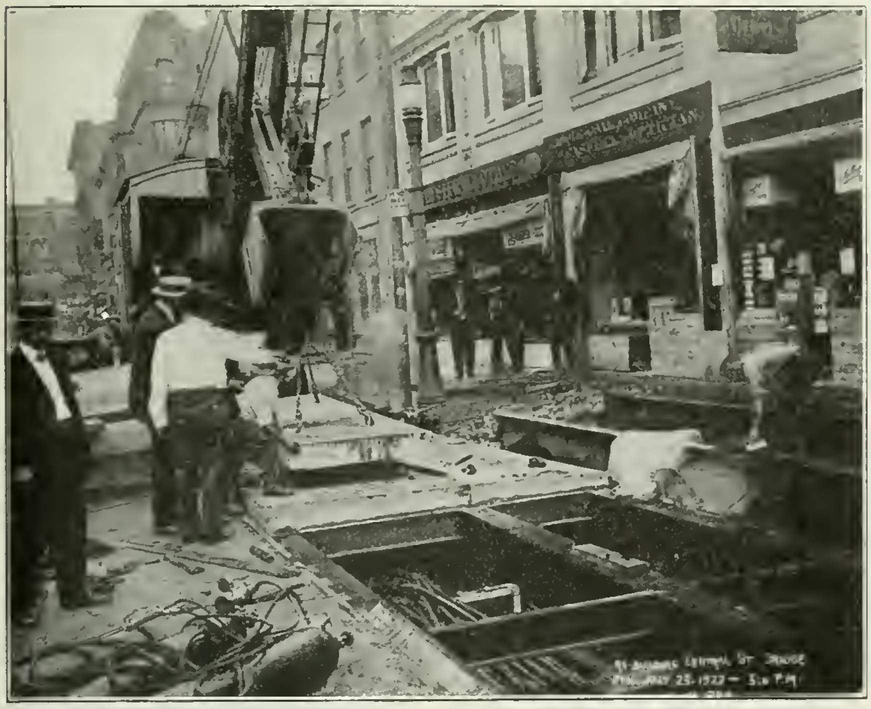
Under an arrangement satisfactory to the proprietors of the locks and canals, the R. E. Runnels Construction Co. of Lowell took the general contract for the reconstruction of the bridge in accordance with the design of the New England Structural Co., with the New England Structural Co. furnishing and erecting the steel work, and the locks and canals setting the base plates and doing other preliminary work.

Preliminary Construction.—The base plates were set during the months of May and June of this year. Some little work was involved, as pockets had to be cut in the masonry abutments, many of which unavoidably came directly under the ends of the old trusses and necessitated shoring up from the bottom of the canal. In addition to this the locks and canals faced up the south abutment with concrete and carried the foundation down to hard pan. The original south abutment consisted of a rough stone wall laid dry and was founded on three to four feet of black muck underlaid with hard pan. About a third of the abutment rested on short piles driven through the muck. The concrete facing put on averaged about a foot in thickness, with a sloping footing four to five feet wide which reached back under the old wall. This work was done in sections on three successive Sundays with the water drawn out of the canals.

The Precast Slabs.—The precast slabs were made by the R. E. Runnels Co. in its yard about ¾ of a mile from the bridge.

1:2:4 concrete was used. Each slab had four U-shaped hooks made of ⅞ in. reinforcing steel cast into it for handling. These hooks were burned off after the slabs were finally placed. Steel curb edgings were cast in the sidewalk slabs to form the curb. After curing for about 20 days the slabs were all raised and their dimensions carefully checked and any irregularities corrected.

With all preparations completed, the week ends of July 16 and July 23 were set for the reconstruction of the bridge. During the days preceding these dates the street railway tracks, including both rails and ties and the planking and pavement between the rails, were all renewed. Both in and outbound cars used the easterly track during the week of July 10 to 15, when the westerly track was relaid, and the situation was reversed the following week. During these periods both sides of the bridge between the tracks and the curbs remained open to traffic.



Placing Precast Concrete Slabs With Steam Shovel.

Removing Old Bridge Deck.—Eleven o'clock Saturday night, July 15, was set as the zero hour for the replacement of the westerly half of the bridge. At that hour the street was entirely closed with the exception of the easterly sidewalk, the New England Structural Co. began the erection of their derrick, and the Runnels Construction Co. started in tearing up the tar concrete wearing surface. It was hard and tough and thick. Two or three hours' work with hammers and wedges made little impression, but yet enough to open up the way for an Erie steam shovel. Holes were cut through the bridge planking after wedging off the tar concrete and through these holes a chain was passed and made fast to the bucket of the steam shovel. "The 3 in. Canada pine, jointed but not planed," which Mr. Francis had laid "on the underplanking of 2½ in. spruce planed to a thickness of 2⅜ in. matched and jointed and laid as tight as practicable and strongly spiked to the stringers" came up reluctantly, but it came nevertheless. The use of the steam shovel reduced this operation which might well have taken a day or two if done by hand to a matter of hours. The steam shovel was also used later for placing the slabs. By eight o'clock on Sunday morning that half of the deck over the southerly span was removed so that the New England Structural Co. was able to start lifting out the old trusses and putting in the new I-beams. The work was carried on continuously through Sunday and Sunday night with the traffic still shut off. When Monday morning came the roadway slabs were all in place and part of the sidewalk slabs. It was then necessary to suspend operations until Monday night in order to open up the easterly half of the bridge for traffic and to place short wooden bridges into the store entrances. The remaining sidewalk slabs were placed in position Monday night, and the kreolite blocks laid. The roadway and one-half of the sidewalk was all completed and opened up at eleven o'clock Tuesday morning. The actual working time required for replacing this half of the bridge was something under 60 hours.

View Taken July 31 Showing Finished Work.

The electric cars were diverted to the rebuilt westerly track on Monday morning and during the week the easterly track was replaced and new pavement laid. During this period, with the exception of Monday, both sides of the roadway and the westerly track were again open for traffic. One way traffic only was permitted on Monday.

The work was repeated in a similar way with the easterly half of the bridge the following week end. Due to the experience gained on the first half of the bridge, the work progressed more rapidly. The old deck was entirely removed by 6 a. m. Sunday, the old trusses all lifted out by 11 a. m., and the new steel work placed and riveted by 7 o'clock Sunday evening. The placing of the slabs began at 4 o'clock Sunday afternoon and was completed by midnight Sunday. This was two hours in advance of a schedule which called for opening the entire bridge for traffic at 8 o'clock Monday morning. But a steady rain Sunday afternoon and night, of course, made it impossible to lay the wood blocks in pitch. It was the middle of the week before the pavement could be laid, although with both the railway tracks and the westerly half of the bridge already completed, the traffic could go in both directions. The remaining half of both sidewalks were poured in place during the week.

Great credit is due the R. E. Runnels Construction Co. and the New England Structural Co. for the energy and ability displayed in carrying out the work substantially in accordance with the original schedule.

Portland Cement Output in October.—According to statistics issued by the U. S. Geological Survey, the production of portland cement in October amounted to 12,287,000 bbl., and the shipments to 12,114,000 bbl. The stocks at end of month totaled 4,157,000 bbl.

Methods of Handling Treated Lumber

Present Practice of 20 Railways Outlined in Committee Report Presented Oct. 17 at Annual Convention of the American Railway Bridge and Building Association.

In the preparation of a report to be submitted at the 32nd annual convention of the American Railway Bridge and Building Association, the committee on "Framing Bridge Timbers Before Treatment," of which A. B. Ilsley is chairman, sent a questionnaire to about 40 different railroads to get information about their present methods of handling treated timber. Replies were received from about 20 railroads. The notes following are taken from the committee report.

Framing Before Treating. — The ideal way to build with creosoted lumber would be to make complete detail drawings of each structure to fit the individual location. This would permit the framing of each member before treating. It would not be practicable to do this with pile structures since it is necessary to cut off piles to proper elevation after they are driven, and also because the piles cannot always be driven exactly in the desired location. For pile structures, then, the ideal way is to drive the piles and cap them, and measure locations, then frame the balance of the structures to fit these locations and then treat the framed lumber. This idea is being carried out on some railroads in building small structures such as highway bridges, water tanks and coaling plants, but it has not been applied generally to bridges and trestles, where the bulk of the lumber is being consumed. In these structures it is the general practice to provide treated lumber in stock sizes and cut and bore in the field as may be necessary.

The replies to the questionnaire indicate a very general use of ballast deck trestles of treated timber, but rather few open deck trestles. They give in a general way the present practice in treating and handling the various classes of bridge and building lumber about as follows.

Piles.—Piles are cut off and bored after they have been treated and driven. Field protection must be relied on to prevent decay starting at the cut surfaces. They usually have to sustain severe moisture conditions, and they should have a good treatment which means a uniform penetration of the oil all the way around.

The committee recommends for land driving, unhewn piles treated by the full cell process with at least enough creosote to penetrate the sap wood completely and not less than 15 lb. per cubic foot for pine or 10 lb. for Douglas fir.

Ties and Guard Sticks.—The replies to the questionnaire indicate that there is some question as to the desirability of treating bridge ties. It is of no benefit to treat timber that will wear out before it will rot if untreated. Ties on open deck structures suffer considerable wear. They are cut by the tie plates and by the spikes, and they are sometimes scarred by derailments early in their life. In fact, it often appears that new bridge decks have to be initiated into service by sustaining a derailment. They are often damaged by running rails and many good bridge ties have been split open and ruined in this way. Furthermore, they are exposed to fire dropping from the locomotive, and it is probable that treated ties, when they are new, form a greater fire risk than untreated ties. On the other hand, there are woods which make suitable ties when treated that are unsuitable when untreated, and it may be that this consideration will control in the future. There is no difficulty in framing ties at the mill before treatment, and dapping them properly to take care of the camber, cover plates and rivet heads, but it is probable that in some cases where the steel work is irregular, the dapping, if not the boring, should be done in the field, if the lumber is pine. If the treating is done at a company owned plant there is no reason why ties after being dapped in the field to fit irregular steel work could not be sent to the treating plant, but if the treating is done at a commercial plant this would usually not be practicable. Ties on timber trestles can be framed and bored complete at the mill before treatment.

Guard timbers can be framed and bored at the mill, but where the tie spacing is irregular, as frequently obtains on metal bridges, it may be necessary to have the framing and boring done in accordance with a carefully prepared drawing.

If it is desired to treat ties and guard rails, the committee recommends the empty cell process (Rueping or Lowry) with not less than 8 lb. of oil per cubic foot for pine lumber and 6 lb. for Douglas fir.

Trestle Stringers.—For open deck pile trestles, when the panel lengths are not exactly regular, it is usually safe to provide the stringers in standard lengths, and to cut and bore them in the field, if the lumber be pine; but with Douglas fir, which lends itself less readily to field treatment, it is advisable to cut and bore to exact length before treating. For open deck frame trestles, the bents can be spaced uniformly, and the timber cut and bored to standard length before treatment. The above holds true also for ballast deck trestles, of the type where the stringers are laid solid and butted over the caps, but in the type where the stringers are laid open and are lapped over the caps with a plank floor, there is no difficulty in framing them complete in standard lengths at the mill before treatment.

For open deck trestles the moisture conditions for the stringers are generally not severe, and the empty cell treatment with about 8 lb. of oil per cubic foot for pine and 6 lb. for Douglas fir seems to be considered adequate by most roads. For ballast deck trestles, however, the moisture conditions are generally more severe, and for pine lumber the plank floor, stringers and bents should generally receive the full cell treatment with a minimum of 12 lb. of oil per cubic foot. For Douglas fir the deck planking of ballast deck trestles should generally receive the full cell treatment of 10 lb. per cubic foot and stringers the empty cell treatment of 6 lb.

Bents.—There is no difficulty in framing and boring bents of frame trestles at the mill, but the members would generally have to be match marked and this adds somewhat to the supervision necessary. For open deck trestles when the bents are alternately wet and dry, treatment by the full process with 12 to 15 lb. per cubic foot for pine and 10 lb. for Douglas fir will usually be necessary.

Longitudinal Struts and Braces.—It is practicable to cut and frame longitudinal struts in standard lengths before treatment, except when they are to be used in connection with pile bents, and the piles have been badly driven. In these cases it may be necessary to cut and bore in accordance with measurements taken in the field.

Bracing planks of pine are usually completely penetrated and may be cut in the field with little danger. Douglas fir planks are, however, not usually completely penetrated, and since it is generally necessary to cut bracing plank in the field, and since this lumber has a fairly long life without treatment, one road recommends against treating Douglas fir bracing plank at all.

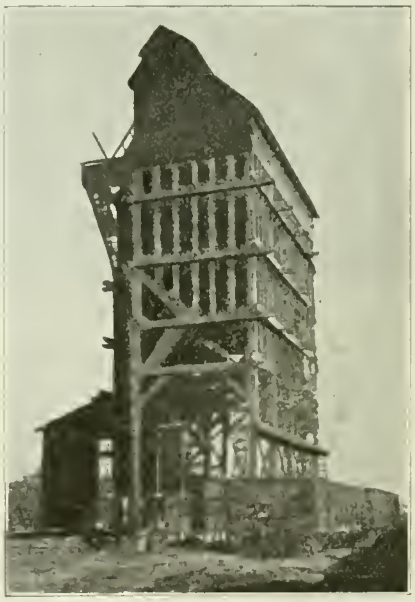


Fig. 1—Ceosoted Timber Coaling at Atlanta, Ga., of N. C. & St. L. Ry.

Foundation Blocks.—While it is practicable to treat the foundation blocks for timber trestles, highway bridges, platforms, etc., it is probably poor policy unless they rest on a firm foundation. A large portion of the cost of maintaining timber trestles consists in lining and surfacing made necessary by the settlement of the foundations, and with structures of treated timber it would be wise to eliminate this cost along with the renewal cost, by building permanent foundations. The committee suggests foundations of concrete or stone rather than blocking.

Miscellaneous Structures.—Some of the roads report excellent results obtained by framing highway truss bridges and wooden water tanks and frames complete before treating. If the structure is complicated, it may be necessary to assemble it complete before treating.

Figure 1 shows a creosoted timber coaling plant which was framed and bored before treatment, excepting only the siding and lining of the pockets.

Highway bridge floor plank can usually be cut to proper length before treating. Platform plank usually cannot, and the notes previously made about bracing plank, apply also to platform plank.

Several roads report extensive use of creosoted wood box culverts, many of which are 25 to 30 years old. The very few instances of failure of these culverts occurred when the timber was cut after treating.

Treating in the Field.—While it is true that most of the failures of treated lumber seem to be attributable to careless handling or cutting in the field, it is also true that it is practicable to protect these exposed surfaces of pine lumber efficiently by coating them in the field. The replies to the questionnaire indicate a fairly uniform practice for protecting creosoted pine lumber in the field which consists in coating the surfaces with 2 or 3 coats of hot creosote oil and then with hot coal tar pitch. This is sometimes followed on ends of piles by a covering of tarred paper or galvanized iron. No instance is reported where treated pine timber cut in the field and protected in this manner has decayed afterwards. For Douglas fir this field treatment should be avoided wherever possible.

Cost Data.—The committee attempted to collect some data on the cost of framing lumber at the mill as compared with the framing in the field, but found that the existing information was meager. The cost of framing as reported runs from $1 per thousand for ties framed by machinery, to $15 per thousand for the general run of bridge lumber framed by hand. One road reports that framing by hand at the mill costs 50 per cent less than framing the same lumber by hand in the field. Another road reports that framing ties by machinery costs about one-half as much as framing them by hand. Figures from another road that has had a great deal of experience, indicates a cost of about $3.50 per thousand for all classes of bridge lumber framed by machinery and that is about one-third what it would cost to frame the same material in the field by hand. The cost figures in a general way indicate economy in framing by machinery, but these figures would be offset to some extent by the cost of preparing drawings, marking the material to show its position in the structure, and selecting it when it reaches the job.

Conclusions of the Committee.—In the replies to the questionnaire, all roads advocate the framing and boring before treatment as far as practicable.

It is practicable to frame and bore before treatment the timber in all classes of railroad structures, but it may be necessary in badly driven pile trestles, if cutting after treatment is to be avoided, to frame certain members in accordance with measurements taken after the piles have been driven.

All treated lumber should be handled carefully. Piles and other heavy sticks are likely to suffer more from rough handling than lighter sticks. They should be handled with chains and not with timber dogs or cant hooks. They should not be dropped from cars as they are likely to be bruised or cracked.

All holes for bolts bored before treatment should be 1/16 in. larger than the bolts. Those bored after treatment should be the same size as the bolt and should be protected thoroughly by pouring hot creosote oil into them. Oil can be poured into horizontal holes by using a bent funnel.

Ties are likely to suffer considerable wear, particularly if proper track fixtures are not used. Tie plates should be used that are adequate in size and without claws to cut into the wood. Spike holes should be bored and filled with creosote oil before driving the spikes. All unfilled holes should be filled with creosoted plugs. Rails should be well anchored on approaches to prevent running as much as possible.

The committee recommends ballast deck trestles as against the general use of open deck trestles of treated timber. While the fire risk with open deck trestles of treated lumber is probably no greater than with untreated timber, when the structure is destroyed the loss is greater. With ballast deck timber trestles experience shows there is comparatively little risk from fire.

The committee recommends against the use of treated lumber with plain lumber in the same structure, in situations where it would be necessary to rehandle and refit the treated lumber when the untreated lumber is renewed.

This does not apply to the use of treated piles used in trestles along with untreated lumber.

Cost of Sand Blast Cleaning of Bridge Steel

The removal of rust and scale and the preparation of the surface are important parts of bridge painting. While this work is often done with the wire brush, steel scrapers and scaling hammers, the sand blast is believed to afford the simplest means for securing an absolutely clean surface. Some interesting figures on a sand blast experiment conducted by the city of Philadelphia on its highway and river bridges are given in a committee report submitted Oct. 17 at the annual convention of the American Railway Bridge and Building Association.

The figures on the Philadelphia work were compiled from records kept by foreman Howard Smith. To Mr. Smith's record was added a charge for foreman and for this charge 30 per cent of his time was assumed a fair distribution to sand blasting. The figures, therefore, cover field costs, including foreman, but do not include office, overhead or depreciation of equipment. The quantities given under the area cleaned were checked in the field. The work done during the period from Dec. 1, 1921, to Jan. 18, 1922, was on a river span. It represents the cost for steel trusses with buckle-plate floor. This portion of the work was cleaned thoroughly, removing all old paint. The total time during which the compressor and sand blast was working amounted to 220 hours.

Gasoline, 831 gal. at from 25 ct. to 27 ct.	$ 213.71
Engine oil, 30 gal. at 55 ct.	16.50
Sand, 52.84 tons at $7.50	396.30
Foreman	73.00
Labor	549.36
	$1,248.87

Area cleaned, 38,000 sq. ft. Cost per sq. ft., $0.033.

This work during the period from April 19, 1922, to May 3, 1922, was also on the river span. The cleaning, however, was not done as thoroughly as during the period from Dec. 1, 1921, to Jan. 18, 1922. The old paint was not removed where it was in good condition. Costs during this period may, therefore, be taken to represent those of cleaning where the old paint has not been subjected to extreme conditions, such as leaks in the floor or locomotive gases and where it is not necessary to clean the entire surface.

Gasoline, 245 gal. at 25 ct.	$ 61.25
Engine oil, 20 gal. at 55 ct.	11.00
Sand, 14.27 tons at $7.50	107.02
Foreman	24.00
Labor	236.30
	$439.57

Total area (spots cleaned), 32,000 sq. ft. Cost per sq. ft., $0.014.

It seems fair to say that about 40 per cent of the 32,000 sq. ft. was actually cleaned or, say, 12,800 sq. ft. Figuring on this assumption the actual cost per square foot cleaned was $0.034 which compares favorably with that of the former period.

Work during the period from May 4, 1922, to May 15, 1922, was on the plate girder span with buckle plate floor on the east approach next to the east shore pier. It also was spot cleaned, that is the old paint which still adhered well to the steel was not removed.

Gasoline, 155 gal. at 25 ct.	$ 38.75
Engine oil, 10 gal. at 55 ct.	5.50
Sand, 7.2 tons at $7.50	54.00
Foreman	27.00
Labor	154.00
	$279.65

Total area (spot cleaned), 18,000 sq. ft. Cost per sq. ft., $0.016.

The work during the period from May 16, 1922, to May 18, 1922, inclusive, was on one of the spans over the Baltimore & Ohio tracks. The type of construction consists of plate girders with buckle-plate floor. The condition of the old paint was bad and the costs are typical of what may be expected where steel work is subjected to heavy locomotive blasts. The entire surface was thoroughly cleaned. The labor cost includes the cost of loosening heavy scale ahead of the sand blast by the use of mauls and chipping hammers.

Gasoline, 60 gal. at 25 ct.	$ 15.00
Engine oil, 5 gal. at 55 ct.	2.75
Sand, 3.72 tons at $7.50	27.90
Foreman	6.00
Labor	78.20
	$129.85

Area cleaned, 3,070 sq. ft. Cost per sq. ft., $0.042

Publications of American Society for Testing Materials.—The Society will issue this year three regular publications. The current Year Book and the 1922 Supplement to the Book of A. S. T. M. Standards were distributed to the members in September. The Proceedings (Vol. 22), about 1650 pages, will be ready for distribution in December. They will be the largest ever published and will contain reports, papers and discussions of outstanding importance and value.

Examination for Architectural Draftsman.—The U. S. Civil Service Commission announces an open competitive examination for architectural draftsman, Grade A. A vacancy under the Public Works Department, for duty at Naval Station, Guam, at $6.80 per diem, and vacancies in positions requiring similar qualifications, will be filled from this examination.

Erection of 410 Ft. Radio Central Towers

Methods Employed in Erecting 12 Towers for New York Radio Station of Radio Corporation of America Described in Tech. Engineering News.

By DAVID S. FINE,
Assistant Erecting Engineer, American
Bridge Co., Philadelphia, Pa.

The New York Radio Station, opened last November by the Radio Corporation of America, occupies a site of 10 square miles at Rocky Point, L. I., located about 70 miles from New York City. The station and its equipment are the last word in high power radio communication. It is the most powerful station so far constructed, and is planned to have finally 72 towers or 12 wings—each radiating from a central power house.

Details of the Towers.—Twelve towers, forming two wings of six towers each, were erected. The towers are located in a clearing and are spaced about 1,250 apart, making length of each wing over a mile. The towers, which are self-supporting, are 400 ft. high, and are provided with cross-arms 150 ft. long. Eight antenna wires are suspended from each side of the cross-arms. The lower 200 ft. of tower was riveted and painted, while the remaining 160 ft., including cross-arm, was bolted and galvanized; this galvanizing eliminating frequent painting which would necessitate shut-downs to permit the painters to work in the high frequency zone near the antenna. The towers are four-legged or square in section, and have fabricated angles for diagonal bracing. The towers are provided with permanent steel ladders which extend from the ground to the cross-arms on outside of tower. The weight of each tower is about 135 tons. The total tonnage in all the towers is 1,615.

The delivering and storage yard was located about four miles from the central power house. Material was here handled by one steel stiff-leg derrick. The steel in the yard was not sorted into 12 towers, but all pieces of one kind were kept together. A road, newly built for the most part, ran from the yard and along the tower line with short tap roads leading directly to each tower. The steel was distributed to the various towers by a number of auto trucks 2½ tons to 7½ tons capacity

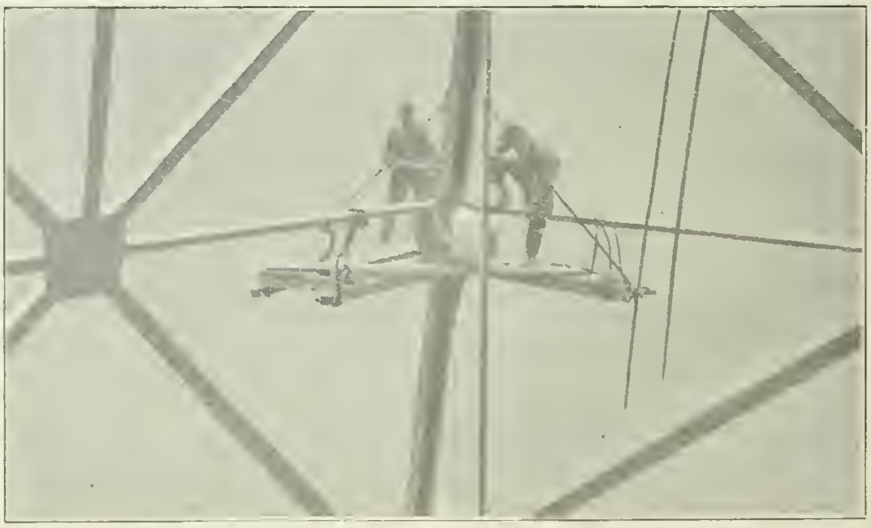
The base of the tower is 60 ft. square and 70 ft. high, a height suitable for gin pole erection. An 80-ft. gin pole composed of 20-ft. sections of heavy 10-in. diameter gas pipe was used, the pole being raised to a vertical position by tripping with another short pole. The gin pole always worked inside of the tower and could be shifted to each corner of the tower or wherever desired. The four triangular corner sections of the base were each held until connected so as to be self-supported by one wire rope guy running back diagonally.

The Floating Gin Pole.—The body of the tower, composed of 10 panels of 30 ft. and one of 40 ft., is 38 ft. square at the top of the base, and 10 ft. square at the top of the tower. It was erected with a floating gin pole, which is similar to the ordinary gin pole except that it is suspended in several sets of falls instead of resting on the ground, and is raised upwards as the erection proceeds. The floating pole was formed from the same 80-ft. gas pipe gin pole used in erecting the base by adding, to the foot of the pole, a steel saucer and fittings for the attachment of the four suspending falls.

The floating pole was rigged entirely with wire rope. It was suspended in four sets of falls composed of two parts of ¾ in. rope, the leads of the falls running to the four spools of the hoisting engine. The top of the pole was guyed and controlled by four sets of falls composed of five parts of ½ in. rope, the lead of each falls running to a winch, one at each corner of the tower. The lower suspending falls were fastened to the tower by means of a wire rope sling wrapped around the tower leg and over the horizontal strut at a panel point, while the upper falls were fastened to the tower at the same point in a like manner with another sling wrapped around the tower leg but under the strut. The bottom of the pole was usually about 30 ft below the horizontal strut. The load line consisted of a single part of ¾ in. wire rope, the lead running outside of the pole.

All steel for the body of the tower was hoisted outside of the tower. The pole would be leaned over, without load, the proper amount, and the steel raised to place as it was outhauled with manila rope tag lines. The horizontal bevel bracing which occurred at every other panel point was not erected until the foot of the pole passed that point, thus avoiding interference of the bracing with the pole.

No elevator was provided for the men, they using the permanent ladder for climbing up the tower, the men being able to climb from the ground to the cross-arm in ten minutes. Signals were given by megaphone which proved more satisfactory than electric bell signaling.

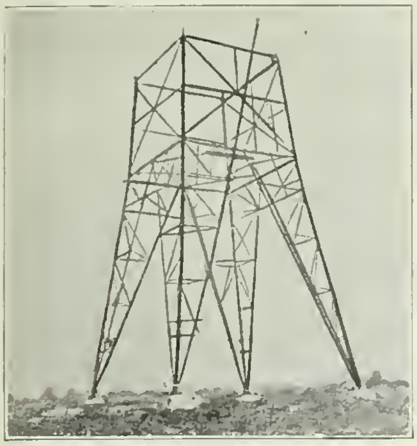


Riveting Scaffold on Radio Tower Erectors.

Method of Erecting Panels.—After erecting a complete panel of tower the floating gin pole had to be raised vertically about a panel height, so as to be in a position to erect the next panel. To do this, the sheave blocks of the upper and lower falls themselves first had to be shifted to the panel point at the next higher horizontal strut. To accomplish this, the pole would be leaned well over to one corner of the tower and while three sets of upper falls hold the top of pole, the block of the fourth or slack set of falls would be unfastened from the tower. The lead line of this falls would then be wound up on its winch, thus shortening the length of the falls and raising the block to the next panel point where it would be fastened to tower. Then the block of the lower falls at the same corner would be raised, but as this set of lower falls was necessary to carry the pole when in an inclined position, it had to be first temporarily replaced by a manila rope falls, after which the block of the lower falls was unfastened from the tower, and by means of the load line of the floating pole was then raised to the upper horizontal strut as the lead of the falls was let out and the lower falls lengthened. When this raising of the upper and lower falls was completed, the pole would be leaned over in the other corners and the operations repeated. The pole would then be placed in a vertical position, and raised upwards about thirty feet by shortening the lower falls through winding their leads on the spools of the engine, while the top guys would be let out. When the pole reached the desired height, the leads of the lower falls would be clamped to the spools. The average time required to shift falls and raise pole was 50 minutes.

Erection of Cross-Arms.—The cross-arm is 150 ft. out to out and is composed of two sections 70 ft. long, connecting to the sides of the tower which itself forms 10 ft. of its length. The two half sections of cross-arm weighed 8 tons each.

A rather unusual and difficult problem was presented in erecting the long cross-arm. While the cross-arm probably could be erected piece by piece by cantilever erection with a traveler working on each side of the tower, such method would be very costly and unsafe, particularly on account of the large number of small pieces composing it and the difficulty of making connections at a considerable height from the ground. An original and unique method, however, was used which permitted the complete assembling of the cross-arm in two sections on the ground and the raising of them bodily to the top of the tower—a method that proved very practical and economical.


Raising Falls of Floating Gin Pole.

The rigging used for raising the sections of the cross-arm was essentially a two-boom guy derrick, the floating gin pole serving as the mast. The booms were 12 by 12 timbers 40 ft long, fitting into foot blocks resting on bearing plates fastened to two stringer timbers 12 ft. long. These timbers in turn were fastened to two 12 by 12 timbers 30 ft. long which were at right angles to the final position of the cross-arm and rested on the top of the tower which was 10 ft. square. The booms were held fixed in position and in line with each other by swing lines running to the ends of the 30-ft. cross timbers. The topping lift consisted of three parts of ¾ in. wire rope and after the booms were set for the proper reach, the leads of the topping lifts were clamped to the spools. The floating ginpole, which acted as a mast, was suspended in the four lower falls and guyed at the top exactly as when erecting the body of the tower. The top of the pole, however, was in addition guyed by four spreader cables which passed over the ends of the 30-ft. cross timbers. The load falls consisted of three parts of ¾ in. wire rope. The timbers and booms with their rigging were placed and dismantled with the floating pole. The pole projected about 30 ft. above the top of the tower; the front reach of the booms was about 36 ft.

Each section of cross-arm was completely assembled and bolted by hand on the ground on its side of the tower at right angles to its final position. To avoid throwing an eccentric load on the tower and to prevent excessive unbalanced stresses in the floating pole and rigging it was necessary when raising the cross-arm on one side of the tower that the effect of its weight be counterbalanced on the other side of the tower. This balance was obtained by simultaneously picking both sections clear of the ground, thus throwing only a downward compressive force on the tower and equal loads on each boom. Then while maintaining this relation, the section of cross-arm on one side was raised to the top of the tower (as the other section hung in the load falls close to the ground), turned at right angles with the tag lines and connected to tower. Then while keeping the strain in this load falls, the other section of cross-arm was raised, turned, and connected. Then the strains in the load falls were released and the rigging dismantled. The time spent in raising and connecting the two sections of cross-arm in calm weather was about four hours.

The base, body and cross-arms of a tower were erected by a gang of 15 men in about 18 days, though the best record made was 14½ days. Three towers were erected at one time.

These towers were designed by the Tower Department of the American Bridge Company, fabricated at their Cambridge plant, and were erected by the Eastern Division Erecting Department, of which J. B. Gemberling is manager. Jerry Kennedy was foreman of erection and the writer was resident engineer

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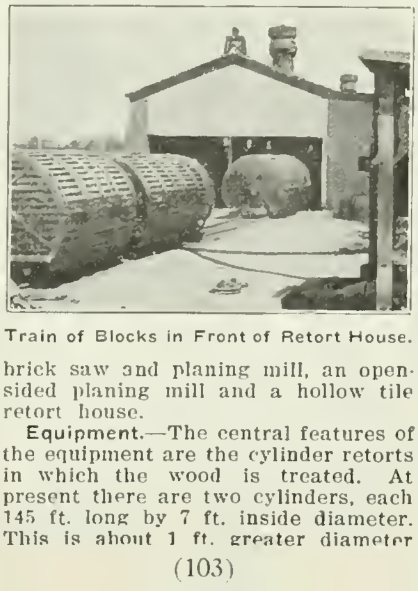
Features of a Modern Wood Preserving Plant and Its Operation

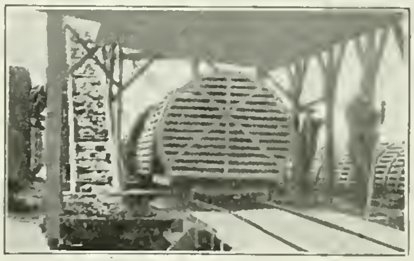
The growing importance of timber preservation has led to the establishment of some very fine plants for the purpose—plants conforming in all respects to modern industrial and scientific requirements, and in marked contrast to the rather crude and makeshift installation which formerly were all that were available and still are in very common use.

The plant of the Republic Creosoting Company at Maywood near Indianapolis was recently visited by one of the editors of Engineering and Contracting, and as it represents a thoroughly modern installation, a short account of the equipment and methods is presented herewith. The construction program for the plant was interrupted by the war, so that the property stands today developed to only a fraction of the capacity which is planned as ultimate. That which has been built, however, forms a complete set of units of the comprehensive plan.

Such a plant at which all classes of materials—blocks, ties, poles, piles, bridge timbers and lumber—are treated, require a large amount of ground space for the handling and storage of both materials and finished product. The principal buildings at the Maywood plant consist of a brick boiler house, a pipe and machine shop, a brick saw and planing mill, an open-sided planing mill and a hollow tile retort house.


Train of Blocks in Front of Retort House.

Equipment.—The central features of the equipment are the cylinder retorts in which the wood is treated. At present there are two cylinders, each 145 ft. long by 7 ft. inside diameter. This is about 1 ft. greater diameter and 25 ft. greater length than is ordinarily employed. The cylinders are of ⅝-in. steel, heavily riveted, and mounted horizontally in concrete settings. They are provided with doors at each end, and a 30-in. gage industrial track runs through each. The doors are hinged, and when closed are fastened with heavy bolts at the circumference. The cylinders are tested to 300 lb. water pressure, which is 120 lb. more than the maximum pressured water used in operation. The warm and substantial construction of the building eliminates the necessity of many special heat insulations on the cylinders.


Loading Treated Blocks Into Freight Car.

There are four 50,000 gal. oil storage tanks and two 100,00 gal. measuring tanks located near the cylinder house. Creosote oil is delivered from railway tank cars on a standard gage track between the retort house and the storage tanks. The oil is handled through 10-in. pipes, of which there are about 3,000 ft. in the various connections.

All the pumps, compressors, etc., are located together in the retort house beside the No. 1 cylinder. This affords a maximum of convenience by concentrating the entire operation and its control at one point. The connections permit oil to be taken from any one of the four storage tanks, and delivered as desired to either of the two cylinders. The connections are, however, considered very simple for such a plant, the valves being located conveniently together between the pumps and No. 1 cylinder.

The pumping and compression equipment consists of one 600 ft., 120-lb Chicago Pneumatic Tool Co. compressor; one Laidlaw feather valve vacuum pump which will raise a vacuum of 24 in. in one cylinder in 20 minutes; one Dean oil pump for filling cylinders—capacity 1,000 gal. per minute against 70 lb. pressure; add four small high pressure pumps for creating and holding pressure after the oil is delivered. A board carries pressure, vacuum and temperature gages for both cylinders. There are three underground storage or accumulator tanks of about 20,000 gal. capacity for holding the surplus oil remaining in the cylinders after treatment is completed. The air connections with the cylinders are by 5-in. pipe.

In developing the plant for maximum efficiency and economy of operation, provision has been made to avoid all waste of oil, the oil which is drained from the cylinders to the accumulator tanks being first treated for the removal of sediment and suspended impurities and then used again. Outside the building is a set of four concrete settling tanks into which the blow-off matter from the pipes is discharged, and in which all blow-off oil is retained, the flow from the last tank being merely clear water.

The planing mill has no especially novel features.

Blocks are cut by a gang of small circular saws, the number of which is varied from 17 for 4-in. blocks to 32 for 2-in. blocks. Lumber for this purpose is delivered after inspection through a roll conveyor which takes it to the saws. An automatic feed carries the lumber through the gang, and the cut blocks are discharged through a chute into approximately cylindrical cages mounted on industrial railway cars in which they are carried to the retorts and treated.

At present the plant is provided with about 5,000 ft. of 30-in. gage industrial railway track laid with 35-lb. rail and equipped with split switches. With the ultimate development of the property this trackage will be increased several times.

Operation.—Street paving blocks and other materials which are to remain exposed to the elements are made from unseasoned stock treated by the full cell process. In this treatment the materials are first subjected to live steam in the retorts to soften the resin in the wood and to open the cells. This is followed immediately by a vacuum to draw off surplus moisture and to leave the cells open for penetration of the preservative. Following the vacuum creosote is pumped into the retorts, raised to a pressure of 180 lb., which is maintained for several hours, the time varying with the condition of the wood. This process leaves the cells of the wood filled with preservative.

The "empty cell" process is used for the treatment of interior flooring block or other wood to be used in interior purposes. The material in this case is first subjected to a natural air seasoning from three to six months. It is then treated in the retorts with creosote oil at a pressure of 150 to 170 lb. at 170 deg. Fahrenheit. The treatment is carried to refusal, that is, until no further absorption of oil takes place at these pressures. This is followed by a vacuum to draw off surplus oils. Speed of operation is necessary in this process in order to avoid swelling while the wood is under pressure.

Ties and long timbers are run into the retorts in trains of industrial cars, and following the treatment are run out at the opposite end on a track which is paralleled by a standard gage siding. They are then moved by a portable derrick directly onto railroad cars for shipment.

Blocks are handled in approximately cylindrical cages of strap iron mounted on the 30-in. gage cars. These cages enter the retorts with a clearance of a few inches all around. The top of each cage is a hinged door which is turned back for loading. Unloading is effected through another hinged section at the side and bottom, and is conducted very speedily and economically by mechanical means. The cars are run onto a spur beside which there is a ditch containing an endless chain conveyor. The lower car door is opened just enough to provide a suitable width of discharge of the blocks onto the conveyor. The discharge is controlled by men working with bars through the openings of the cage. As the operation progresses the track is tilted toward the conveyor at a considerable angle, thus making the discharge of blocks complete.

The conveyor runs to a frame about the height of a box car door from which the blocks are delivered and stowed in the car by further automatic means. Refuse from the planing and sawmills is sufficient to supply practically all necessary fuel. Power for these mills is furnished by a Corliss engine located in the basement of the mill building.

The preservative used at the Maywood plant is a heavy creosote oil without any admixture of tar. Paving blocks are treated to leave a final retention of 16 to 20 lb. of oil per cubic foot. Factory floor blocks are given a final retention of from 6 to 8 lb.

Comparative Earnings of Office Buildings 5 to 30 Stories High.

An interesting calculation of the earnings of a typical office building from 5 to 30 stories in height is given by Mr. George C. Nimmons in an article in the November Journal of the American Institute of Architects. The calculations were made by Mr. Nimmons while serving upon a committee of the Chicago Real Estate Board to study the question of building heights for the new zoning laws of Chicago. We quote from the article as follows:

As a large percentage of Chicago's important office buildings are built in the form of a hollow square, that type of plan was adopted. It was assumed that the site was a corner lot 160 ft. x 172 ft. with streets on two sides, an alley on the third and adjoining property on the fourth. The land value was placed at $1,500,000, the cost of the building 60 ct. per cubic foot plus variations for its different heights, and the income at an average of $3.00 per square foot for office space and $5.00 for shop or store space. Taxes, insurance and operating costs were included at the average local rates. Depreciation of the value of the building was not included.

In order to determine the earning power of buildings of different heights erected upon this same lot, calculations began with a 5-story building and were carried through to show what the annual income, expenses, and net profit would be. The same calculations were made for a 10, 15, 20, 25 and 30-story building.

In making these calculations, the cost of the mechanical equipment and the structure of the lower part of the building was increased as the building was carried up higher. Deductions from rentable area of typical floors were also made for the increase in the size of the light court in the upper floors, and for the increase in the

STATEMENT SHOWING THE COMPARATIVE EARNINGS OF BUILDINGS FROM 5 TO 30 STORIES ON AN ASSUMED TYPICAL PLOT.

LAND CONSTRUCTION COSTS:	5 Stories	10 Stories	15 Stories
Value of land	$1,500,000	$1,500,000	$1,500,000
Cost of building	1,108,000	2,054,000	3,000,000
Total land and construction costs	$2,608,000	$3,554,000	$4,500,000
OVERHEAD AND ANNUAL EXPENSE:			
*Interest on loan at 5½ per cent	$ 60,940	$ 112,970	$ 148,500
**Interest on second mortgage at 7 per cent	....	....	21,000
Ground lease, average annual rate	54,000	54,000	54,000
Taxes at 3½ per cent (on 65 per cent land, con. cost)	59,332	80,854	102,375
Insurance at 2 ct. sq. ft. rental area	2,019	3,704	5,381
Operating expense at 62 ct. S. F. rental area	62,584	114,824	166,808
Total overhead and annual expense	$ 238,875	$ 366,352	$ 498,064
INCOME:			
†Rentable offices area at $3 sq. ft	$ 152,644	$ 381,132	$ 608,810
†Rentable store area at $5 sq. ft	199,836	198,180	196,020
Total income	$ 352,480	$ 579,312	$ 804,830
Deduct: Overhead and annual expense	238,875	366,352	498,064
Annual net earnings	$ 113,605	$ 212,960	$ 306,766
Earnings on total investment	4.36%	6.00%	6.82%
Rentable area, square feet office	56,535	141,160	225,485
Stores	44,408	44,040	43,560
Total rentable area, square feet	100,943	185,200	269,045
Number of elevators	3	6	10

LAND AND CONSTRUCTION COSTS:	20 Stories	25 Stories	30 Stories
Value of land	$1,500,000	$1,500,000	$1,500,000
Cost of building	3,935,000	5,013,000	6,281,000
Total land and construction costs	$5,435,000	$6,513,000	$7,781,000
OVERHEAD AND ANNUAL EXPENSE:			
*Interest on loan at 5½ per cent	$ 179,355	$ 214,929	$ 256,773
**Interest on second mortgage at 7 per cent	47,180	77,364	112,868
Ground lease, average annual rate	54,000	54,000	54,000
Taxes at 3½ per cent (on 65 per cent land, con. cost)	123,646	148,171	177,018
Insurance at 2 ct. sq. ft. rental area	6,930	8,308	9,368
Operating expense at 62 ct. S F. rental area	214,836	257,545	290,396
Total overhead and annual expense	$ 625,947	$ 760,317	$ 900,423
INCOME:			
†Rentable offices area at $3 sq. ft	$ 819,261	$1,006,547	$1,150,902
†Rentable store area at $5 sq. ft	193,860	191,700	189,540
Total income	$1,013,121	$1,198,247	$1,340,442
Deduct: Overhead and annual expense	625,947	760,317	900,423
Annual net earnings	$ 387,174	$ 437,930	$ 440,019
Earnings on total investment	7.05%	6.72%	5.65%
Rentable area, square feet office	303,430	372,795	426,260
Stores	43,080	42,600	42,120
Total rentable area, square feet	346,510	415,395	468,380
Number of elevators	14	18	22

*Based on 60 per cent of land and construction cost, except for 5- and 10-story buildings, in which case loan principal is actual "Cost of Building."

**Based on difference between loan principal and "Cost of Building."

†Includes deduction of 10 per cent to cover vacancies.

number of elevators required. The effect of the different heights was thus applied to the same lot, giving an equitable comparison, which is not the case in a comparison of the earning power of existing buildings of varying heights on different sites. The earning power revealed in these calculations was very surprising in some respects, for the rate of earning on the capital invested reached its maximum at a much lower height than was expected.

The calculations show that the 5-story building earns annually 4.36 per cent on the capital invested, the 10-story 6 per cent, the 15-story 6.82 per cent, the 20-story 7.05 per cent, the 25-story 6.72 per cent and the 30-story 5.65 per cent. The outstanding feature of these calculations is that the building is shown to reach its maximum rate of earning at about the twentieth story, and that the rate of earning of the 15-story building is only 0.23 per cent lower than the 20-story building. In this connection it should be recalled that the common idea about the earnings of office buildings is that the higher you build the more is earned on the particular piece of property in question. This is quite true in respect to the lump sum, but in the calculations under consideration, the rate of earning on the total money invested begins to decline as soon as the twentieth story of height has been passed. For example, the investment represented by the 20-story building and the land is $5,435,000, and for the 30-story building $7,781,000, but the rate of earning for the 20-story building is 7.05 per cent, and for the 30-story building only 5.65 per cent. This is the vital point in the whole question, viz., that an excessively high building does not, under ordinary conditions, earn as high a percentage on the money invested as one of medium height, and that there is no justification from an economic standpoint to oppose the restriction of building heights to a reasonable limit in the new zoning laws. In fact, the best argument in favor of this policy is that it will be a positive gain for an owner to build two lower buildings in different locations rather than to build one extremely high one. For example, if an owner were to build two 15-story buildings under the same conditions as herein described he would earn 6.82 per cent on the total investment, while if he built one 30-story building he would not make an earning of 5.65 per cent.

Bond Strength of Wood Piles in Concrete

Tests Made By Milwaukee Sewerage Commission Described in October Proceedings American Society of Civil Engineers

By R. R. LUNDAHL,
Division Engineer, Sewerage Commission,
City of Milwaukee, Milwaukee, Wis.

While plans and specifications were being made by the Sewerage Commission of the City of Milwaukee for the new sewage disposal plant, the question of "the bond strength of wood piles in concrete" had to be considered.

The new plant is to be built at the eastern edge of the city, on what is now a peninsula bounded on one side by Lake Michigan and on the other two sides by the Kinnickinnic and Milwaukee Rivers, respectively. The main part of the plant is to be located on made land, within a pile bulkhead and steel sheet-piling coffer-dam, extending 1000 ft. into Lake Michigan along the south Harbor Entrance Pier. The coffer-dam has been built, and the area within it has been dredged to the average elevation of the bottom of the aeration and sedimentation tanks that are to be constructed therein.

It will be necessary to place the tanks on pile foundations. With a 16-ton load on each pile, the dead weight of the tanks and the sewage, when the tanks are full, requires an average pile spacing of 5-ft. centers. The weight of the tanks, when empty, is not sufficient to overcome the buoyancy, therefore, it is necessary to anchor the structure to the pile foundation. With a 5-ft. pile spacing, the uplift on each pile averages 6 tons, and the question arose as to whether the skin friction or bond strength of a plain wooden pile in concrete was sufficient to withstand this uplift. A thorough search for information on this subject was made, but no data applicable to the conditions were found.

The engineers of the Sewerage Commission favored the use of a mechanical anchorage of some type, although other engineers believed that such anchorage was unnecessary. A majority, however, seemed to favor the deformed type of mechanical anchorage, and this brought up the question of cost. The cheapest method of deforming a pile-head meant an additional cost of at least $1 per pile. As there are about 24,000 piles to be driven, this would entail a minimum additional cost of $24,000, and more elaborate methods of deformation would run as high as $2 or more per pile. This additional expense was not justified without further investigation, because there was no assurance that the deformed anchorage would serve the purpose any better than the plain pile-head.

It was decided, therefore, that a series of tests should be conducted, in order to determine whether any type of mechanical anchorage was necessary and the writer was entrusted with the carrying out of these tests.

The Test Specimens.—Thirteen cedar posts, ranging from 6 to 7½ in. in butt diameter, were selected for test specimens. Cedar was chosen because it was available and it was thought that if the tests proved satisfactory on a soft wood, harder woods could be used with a considerable factor of safety. The posts which had been cut in the winter of 1919 and 1920 and stored in the open, were selected at random from a stock pile, the only requirement being that they should be straight.

The posts were prepared for thirteen types of anchorage, some of which differed only slightly. These types will be explained as the results of each test are given. The butts of the posts were cut square, so that a fresh area of the end of the post would be exposed to the concrete, thus giving a condition similar to that when a pile is cut off at grade before it is covered with concrete. The posts were embedded 1 ft. deep in a slab of concrete 4 ft. square and 1 ft. thick, with a sub-slab, directly under the post, 2 ft. square and 1 ft. thick, cast with the larger slab. The object of the sub-slab was to prevent uneven curing effects around the end of the post and to give a condition similar to that obtained in practice. A 1:2:4 mixture of concrete, with washed sand and crushed gravel as the aggregate, was used. The concrete was mixed in a one-bag mixer, and conveyed in a car to a platform, from whence it was shoveled into the forms by hand. The specimens were made in the Casting Plant of the Sewerage Commission, in March, 1921. The building was heated so that there was no possible danger from freezing. The forms were extended about 6 in. above the slab in order that the concrete might be cured under water for 30 days, thus giving a condition similar to that expected in subaqueous work.

Test No. 1.—The specimen for this test was 7⅛ in. in diameter at the butt, and 7 in. at the concrete surface. The butt was immersed in water for 7 days before it was concreted. This, in the writer's opinion, was the worst conditon that could obtain. The concrete was poured on March 24th, 1921, and the specimen was tested on April 27th, five weeks later.

In order that any movement of the concrete could be noted, the loading box was blocked up 6 in. above the slab. Another box or shield was built around the post so that no frictional resistance would be caused by the material against it. The net weight per vertical foot of load in the box was 2797 lb., the box weighed 475 lb., and the concrete anchorage 2960 lb. The loading of the specimen to the capacity of the box was completed about 11:00 a. m., April 27th, the total load being 14,760 lb. No movement had been noted at noon, but some time between noon and 2:00 p. m., the specimen failed, and as no one witnessed the failure, the time the load had been sustained, could not be determined.

The bond area of this specimen was 266 sq. in., and the failure occurred under a sustained load, for bond, of 55.5 lb. per sq. in. The results of the other tests showed that, as far as bond strength was concerned this specimen was tested under the worst condition possible.

Test No. 2.—Specimen No. 2 was similar to Specimen No. 1, except that it was not immersed in water before it was placed in the concrete. The diameter at the butt was 6¾ in. and at the concrete surface, 6⅝ in., and the bond area was 252 sq. in.

The loading was started on May 2d, 1921, the specimen having aged 5 weeks and 5 days. In order to determine the exact point of failure, the load was applied as shown in Table I.

At 21,000 lb., the capacity of the crane had been reached, and this load was allowed to remain until 8:00 a. m., May 14th, when the specimen was lowered and the load removed. A bond strength of 83.3 lb. per sq. in. had been developed with no sign of failure.

It was decided to move all the specimens to the open, build a gallows-frame strong enough to carry a much heavier loading, and use billet steel for loading purposes. The concrete blocks were covered with about 6 in. of wet sand to prevent schrinkage in the posts. In spite of this precaution, considerable shrinkage took place.

The test of Specimen No. 2 was resumed on June 1st. A 10,200-lb. load was placed on the specimen by 5:00 p. m., and allowed to remain over night. On examination at 8:00 a. m., June 2d, a slight cleavage was noted. When the load was increased to 13,000 lb., the post pulled from the concrete about ⅛ in. When the load was increased to 16,000 lb., the movement was about ¼ in., but it was so gradnal that it could not be observed during the loading. The load was then increased, in 360-lb. increments, to 19,500 lb., at which loading, the post was pulled entirely from the concrete.

A 21,000-lb. load had been applied previously on this specimen without any sign of failure, and the cause of failure at a lesser load is attributed to the shrinkage of the post during the 18 days it had been in the open without being kept wet, except for the moisture in the sand covering. The weather during this period was exceptionally warm most of the time, and the slight rainfall drained off quickly.

Test No. 3.—Specimen No. 3 was immersed in water for 7 days before it was concreted. The diameter at the butt was 7⅞ in. and, at the concrete line, 7⅜ in. The concrete had aged 71 days when the loading of the specimen was started on June 2d. The load was placed in 360-lb. increments and totaled 17,400 lb., at 6:30 p. m. No failure could be noted, and the load was allowed to remain until noon the following day, when it was observed that the post had pulled ⅛ in. from the slab. The failure, under a sustained load of 17,400 lb., was equivalent to a bond strength of 60.6 lb. per sq. in. The load was increased to 20,300 lb., and the post pulled gradually to ¼ in., which was considered sufficient evidence of failure, and further operation was discontinued.

TABLE I.

Load, in pounds.	Time.	Date.	Hours load was sustained.
7,200	9:00 a.m.	May 2, 1921	6
8,300	3:00 p.m.	May 2, 1921	23
9,700	2:00 p.m.	May 3, 1921	21
10,200	11:00 a.m.	May 4, 1921	5
11,000	4:00 p.m.	May 4, 1921	19
11,500	11:00 a.m.	May 5, 1921	5
12,000	4:00 p.m.	May 5, 1921	43
13,400	11:00 a.m.	May 7, 1921	21
12,500	8:00 a.m.	May 8, 1921	31
13,700	3:00 p.m.	May 9, 1921	22
14,100	1:00 p.m.	May 10, 1921	23
14,800	12:00 noon	May 11, 1921	48
19.500	12:00 noon	May 13, 1921	1½
21.000	1:30 p.m.	May 13, 1921	18½

To guard against the conditions in Test No. 2, the remaining test specimens were thoroughly soaked, and the result of Test No. 3 shows that it was helpful.

Test No. 4—Specimen No. 4 was dry when the concrete was poured and had aged 72 days when the loading was started at 3:30 p. m., on June 3d. The diameter of the post at the butt was 7⅝ in. and, at the concrete line, 7¼ in. A 16,000-lb. load had been applied by 8:30 p. m., with no indications of failure. This load was allowed to remain until 10:00 a. m., June 4th, 13½ hours, but no signs of failure were noted. The load was increased to 19,520 lb. and allowed to remain until noon, June 6th, at which time the bond strength appeared to have failed slightly, but there was some doubt as to this fact. The load, therefore, was increased to 23,840 lb., at which a slight movement was noted, and at 25,640 lb., the post had been pulled ¾ in. The specimen was now unloaded, and it was settled definitely that failure had occurred at 19,520 lb. which was equivalent to a bond strength of 69.7 lb. per sq. in.

Test No. 5—Specimen No. 5 was 7 in. in diameter at the butt and 6 11/16 in. at the concrete line. The concrete was banked up about 4 in. around the post in the form of a cone. The idea was that the area of concrete in contact with the pile would be increased at little added expense. This method was considered to be the next cheapest, if the results of the tests on the plain anchorages proved to be inadequate.

This specimen had aged 75 days when the loading was started at 7:45 p. m., on June 6th. At 8:30 p. m., a load of 10,960 lb. had been applied, which was allowed to remain until noon on June 7th, with no sign of failure. The load was then increased to 25,640 lb. by 8000, 5000, and 2000-lb. increments, respectively, and at 7:00 p. m., the first sign of failure was noted. Further loading to 28,160 lb. resulted in the failure of the cedar post in tension.

If the embedded depth of the post is taken as 12 in., a bond strength of 100 lb. per sq. in. was developed. If the embedded area of the post is used, the bond strength was 75.8 lb. per sq. in. The cedar post failed in tension under a unit stress of about 850 lb. per sq. in.

Test No. 6.—Specimen No. 6 was of the same type as Specimen No. 5, but had a slightly larger butt diameter. The concrete had aged 79 days when the loading was started at 9:00 a. m. At 11:00 a. m., a load of 16,200 lb. had been applied when the first sign of failure was noted. A bond strength of only 60.0 lb. per sq. in. had been developed.

The load was increased to 23,120 lb., at which the post pulled from the concrete. The post was found to be sound, but there had been no bond to the bottom of it, whereas, in the other tests, this was not the case. The area of the bottom of the post was about 33 sq. in., and the bond on this area would have had a material affect on the total load sustained.

In the foregoing tests, the unit stresses have been calculated from the areas of the sides alone, but the bond to the bottoms undoubtedly plays an important part. The exact relation could not be determined except by tests.

When Specimen No. 6 was concreted, the post settled so that it was embedded more than 12 in. in the concrete. Accordingly, it was pulled up to the 12-in. mark. In doing this, the bond to the bottom of the post must have been destroyed. The results seem to indicate that the bond to the end fibers plays a more important part than that to the sides of the post.

Conclusions for Test Specimens Nos. 1 to 6.—Tests Nos. 1 to 6 complete all those without any type of deformed anchorage. The conclusions from these tests are that the enlargement of the pile-head has no effect on the load sustained until the bond strength has failed. In every test, it was noted that, when the bond failed, the concrete usually dropped suddenly about ⅛ in., and then continued to move slowly to ¼ in. Between the ⅛ and the ¼-in. movement, the enlargement of the head became effective. In nearly every case, after this point had been reached, the load was applied without additional failure until the post either broke or pulled from the concrete.

The writer believes that as long as the concrete adheres to the bottom of the post, there is no chance for the fibers to compress. This is probably the cause of the sudden drop as soon as the bond has failed. The load necessary to overcome the bond was sufficient to compress the fibers enough to allow the concrete to drop the ⅛ in. After this, an additional load was necessary to compress the fibers sufficiently to allow the post to be pulled even slightly.

A movement of ⅛ in. might be injurious to a structure, and where it is necessary for the piles to withstand any upward pressure, it is unsafe, therefore, to consider anything but the bond strength of the concrete to the wood pile. It would seem safe to consider the bond strength of the concrete to the wood pile to be 50 lb. per sq. in., which is below any of the results obtained, but the entire static head should be used in designing, in order to obtain an additional factor of safety.

Whether a pile of larger diameter than those used would develop a similar bond strength can be determined only by tests. The Sewerage Commission intends to conduct a series of such tests, in order to secure this information.

Tests on the Deformed Specimens.

Test No. 7.—Specimen No. 7 had an average butt diameter of 6¾ in. and no enlargement. Four 3-in. track spikes were driven, 90° apart, into the butt, the heads extending about 1 in. for anchorage. The concrete in this specimen had aged 80 days, and the test was started at 8:30 a. m., June 10th. At 11:00 a. m., after a load of 16,640 lb. had been applied, the first sign of failure was noted, the post having pulled about ⅛ in. The load was increased to 17,360 lb., and as the post continued to pull from the concrete, the test was stopped. The bond area, on the sides, was 257 sq. in., and the bond stress developed was 64.7 lb. per sq. in.

Test No. 8.—This specimen had a diameter of 7 1/16 in. and an enlargement of 3/16 in. A 1-in. pin, 30 in. long, was passed through a 1-in. hole drilled through the post 6 in. from the bottom. About 1 ft. of the pin extended from each side of the post. The concrete had aged 81 days when the loading was started at 1:45 p. m., June 10th. At 4:00 p. m., a load of 18,080 lb. had been applied and no signs of failure had been noted. This load was allowed to remain until 8 a. m., June 11th, when it was increased to 22,040 lb., under which, at 8:50 a. m., the first sign of failure was observed. The load was increased to 22,400 lb. and the post pulled about ⅛ in., which load is equivalent to 84.4 lb. per sq. in. on the bond area.

The test was stopped, as it had already failed beyond the point of safety. No doubt, the pin through the post increased the load that this specimen could sustain. After the failure of the bond, which probably occurred before the line of fracture was noted, the specimen held until the fibers in contact with the pin had compressed. When this occurred, the post pulled from the concrete and the line of failure was noted.

Test No. 9.—Specimen No. 9 had an average butt diameter of 7⅛ in., and 1 ft. from the butt, it was sawed on two opposite sides to a depth of 1 in. The wedges thus formed, tapering to 1 in. at the concrete line, were then chopped out, thus making the post 7⅛ in. in diameter at the butt, and, at the concrete line, a flattened ellipse, 5 by 7 in.

The concrete had aged 81 days when the loading was started at 11:30 a. m., and by 2:00 p. m., a load of 16,280 lb. had been applied when the first sign of failure was noted. The bond strength developed was 61.2 lb. per sq. in. The load was increased as follows: 17,360 lb., ¼-in. movement; 18,080 lb., ⅝-in. movement; and 18,520 lb., 1-in. movement. At 22,400 lb., the post pulled from the concrete. Examination disclosed that there had been no shearing action; the fibers had been compressed, and pulled through the 5-in. hole in the concrete.

The preparation of piles in this manner would be expensive, and the results of the test show that this added expense would be unwarranted.

Test No. 10.—This specimen was 6⅝ in. in diameter and had been expanded by driving a 1 by 12 by 6½-in., hard-wood wedge flush with the butt, thus making the bottom of the post elliptical in shape, 6⅝ by 7⅝ in. Before the wedge was driven, a band was placed around the post at the concrete surface, which band was not removed during the test. This specimen was 83 days old. The load was started at 8:45 a. m., and by 11:15 a. m., the first sign of failure was noted with a load of 15,920 lb., which is equivalent to a bond strength of 63.7 lb. per sq. in. Under a load of 18,800 lb., the post had pulled ¼ in., and ¾ in. with 20,240 lb. It was seen that this method did not increase the bond strength, and the loading was not continued.

Test No. 11.—Specimen No. 11 was trimmed to a wedge shape on four sides, instead of two sides, as was done with Specimen No. 9. The average diameter of the butt was 6½ in. and, at the concrete line, the post was about 4½ in. square.

The concrete in this specimen had aged 84 days and the first sign of failure was noted with a load of 13,760 lb. With a bond area of about 244 sq. in., this load was equivalent to 56.4 lb. per sq. in. From this result, it is obvious that the trimming of a pile-head to this shape would not be justified. When the load was increased to 18,080 lb., the post pulled from the concrete about ¼ in., and at 22,400 lb., it pulled ½ in. After remaining for 2 hours without further movement, the load was increased to 23,840 lb., at which the post parted at the concrete line, under a load of 1180 lb. per sq. in.

Test No. 12.—Specimen No. 12 was prepared by driving two wedges in the butt at right angles to each other. An iron band was placed around the post, 1 ft. from the butt, before the wedges were driven. The band was used to give the same results as would be obtained from the soil around the pile-head if the wedges were driven in the field, after the piles were in place. On this specimen, the band was removed before the test was started.

This test began on June 14th, at 3:00 p. m., and continued, with 360-lb. increments, until noon, on June 15th, when the first sign of failure was noted with a load of 15,200 lb. The average diameter at the butt was 6¾ in., and the bond area, disregarding the increase in size due to the wedges, was 240 sq. in., thus giving a unit bond strength of 63.3 lb. per sq. in.

In Test No. 10, with one wedge, the unit bond strength was 63.7 lb. These results would indicate that there would be no reason for using more than one wedge. This method of deformation would be considerably cheaper than trimming the post to a wedge shape, and also gives a higher unit strength, but there is no indication that the bond strength would be any greater than that in an anchorage without any deformation.

The driving of wedges in the pile-heads would not injure the original surface fibers, as would be the case if the methods in Tests Nos. 9 and 11 were followed; but there would always be some "give" between the post and the wedges, and, as the load was applied, this "give" would cause the bond to break sooner than in a solid post.

Test No. 13.—In Specimen No. 13, two 1-in. pins at right angles to each other had been driven through holes in the post, 6 in. from the butt. The pins extended 1 ft. into the concrete, on four sides.

The post had a slight butt enlargement, an average diameter of 6½ in., and a bond area of 240 sq. in., after deducting for the area of the pins. The loading was started on June 16th at 8:00 a. m., and by 11:00 a. m., a load of 15,920 lb. had been applied, when failure was noted. This load was allowed to remain, but no further failure occurred. A bond strength of 66.3 lb. per sq. in. had been developed, but the failure had been so slight that the movement would not have been injurious to any structure. In fact, there was a question as to whether the slight fracture noted was really a failure due to the pulling out of the post, or whether it was due to the elongation of the wood fibers at the concrete line. The latter cause would seem to be the more plausible, because, under continued loading, no further movement was noted.

Under a load of 20,600 lb., the post parted, and the movement at the concrete line was found to be small. A bond strength of about 86 lb. per sq. in. had been developed without an injurious amount of movement.

The pin types of deformation are by far the cheapest that were tried, and the results indicate that only one pin would be necessary, if it was decided that a deformed anchorage was needed.

Description of Testing Apparatus and the Method of Testing.—Fig. 1 shows the testing apparatus. The gallows-frame was designed to carry a load of 40 tons.

The method of testing was as follows: A locomotive crane would swing the specimen under the frame so that the pin could be inserted through the sling and the shackle-plates, the sling being of such length that the specimen was clear of the ground when it was released by the crane. The steel billets, each of which weighed 360 lb., were handled by a block and tackle running on a trolley. They were lowered with the least possible jar to the specimen and were racked so that a clear space was left around the post for observation and as a guard against friction of the load on the post. The post and the concrete adjacent to it were thoroughly chalked before loading was started, in order that any movement could be better detected. The incre-

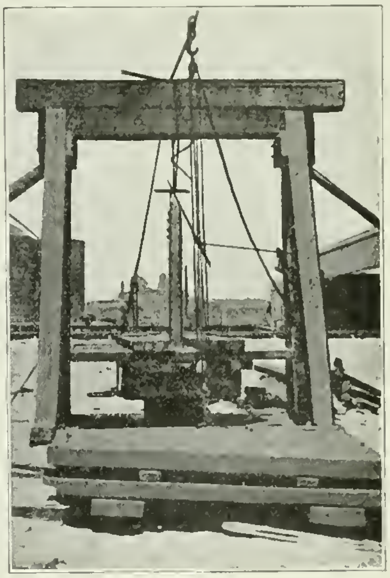


Fig. 1—The Testing Apparatus.

TABLE II—RESULTS OF TESTS TO DETERMINE BOND STRENGTH OF WOOD PILES IN CONCRETE.

Test no.	Type of anchorage.	Diameter at butt, in inches	Diameter at concrete line, in inches	Enlargement, in inches.	Total load sustained, in pounds.	Area in square inches of sides in bond.	Area of butt, in square inches.	Bond strength (sides), in pounds per square inch	Bond strength, sides and bottom, in pounds per square inch	Remarks
1	No deformation.	7⅛	7	⅛	14 760	266	39.9	55.5	48.2	Pile butt soaked for 7 days before being concreted
2	"	6¾	6⅝	⅛	21 000	252	35.8	83.3	72.9 cu ft dry	
3	"	7⅞	7⅝	¼	17 400	287	48.7	60.6	51.8	Pile butt soaked as in Test No 1.
4	"	7⅝	7⅛	½	19 520	280	45.6	69.7	59.9	Butt dry.
5	Concrete banked up about 4 in.	7	6 13/16	3/16	25 640	258–338	38.5	100–75.8	68.1	Post pulled apart at 28 160 lb
6	Concrete banked up about 4 in	7¼	7⅛	⅛	16 290	276	41.2	59.0	..	No bond to the bottom.
7	Four small track spikes driven	6⅞	6⅝	¼	16 640	257	37.1	64.7	56.6	Total movement ¼ in at a load of 17 360 lb
8	1 in pin through butt one way	7 3/16	6⅞	5/16	22 040	260	39.0	84.4	74.0	Total movement ⅛ in., load of 22 400 lb.
9	Trimmed to a wedge shape on two sides	7⅛	7	⅛	16 280	266	39.9	61.2	53.2	Post pulled out, load, 22 400 lb
10	Expanded 1 in by wedge driven into butt	6⅝	6⅝	None	15 920	250	34.5	63.7	55.9	Total movement ¾ in., load 20 240 lb
11	Butt trimmed to wedge shape, four sides	6⅝	6⅝	⅛	13 760	244	34.5	56.4	49.4	Post broke at top of concrete, load, 23 840 lb
12	Butt expanded two ways by two wedges	6⅝	6⅝	None	15 200	240	31.9	63.3	55.9	Post pulled out, load 25 280 lb.
13	Two 1-in pins at right angles through butt	6⅝	6⅝	⅛	15 920	245	34.5	66.3	57.0	Post broke at load of 20 600 lb. Movement at breaking point very slight.

ments of load were applied slowly, and as the point of failure was reached, the specimen was closely watched for any sign of such failure. As soon as the slightest line appeared, the loading was stopped for a time, in order to allow the post to pull as much as possible under that load. The points of failure were determined closely from the results of the test on Specimen No. 2 which was loaded in small increments and allowed to stand for several hours before additional load was applied.

Conclusions.—Table II gives the results of the tests and affords an opportunity for comparing the different types of anchorage tested, for drawing conclusions as to the best types to be used, and for determining a safe average bond strength to be used in designs where it is necessary to use the factor of bond strength.

The average bond strength of nine of the tests, not including those immersed in water and those with the pins, was 66.3 lb. per square inch, when the side area only is considered. Using the combined area of the side and bottom, the average is 58.9 lb. per square inch. For the piles without deformed anchorage, that is, the first seven, not including the specimens that had been immersed, which are obviously low, but including the test with the spikes, the average strength is 70.5 lb. per square inch, whereas the average of the deformed anchorages is only 65.9 lb. per square inch. These results indicate that deformation of the pile-heads has a tendency to decrease the bond strength.

The average strength of the two plain anchorages, Tests Nos. 2 and 4, is 76.5 per square inch, whereas the average of the two highest tests of deformed heads, the two with pins, is 75.3 lb. per square inch. Therefore, the results shown by the best deformed types are not as good as those found with the two plain anchorages.

In conclusion, it may be stated that only the bond strength of the wood to the concrete should be considered. The deformation of the pile-heads does not warrant the added expenditure it will entail. If the substance to be anchored is of metal, a deformed anchorage will be beneficial.

The writer believes that the Sewererage Commission will not consider the use of deformed pile-heads, but will rely on the bond of the concrete to the pile. The piles to be driven will have an average butt diameter of at least 12 in. and are to be embedded to a depth of 10 in. in the concrete. The side area, in bond, is 377 sq. in., and with 12,000 lb. of uplift per pile, a bond strength of 31.9 lb. per square inch is necessary. This is less than the lowest result obtained in any of the tests.

The work that brought about the foregoing is being done for the Sewerage Commission of the City of Milwaukee under the direction of T. Chalkley Hatton, M., as Chief Engineer, with James L. Ferebee, M., as Principal Assistant Engineer.

Some Physical Properties of Paints

Abstract of a Paper Presented June 29 Before the American Society for Testing Materials

By P. H. WALKER and J. G THOMPSON.

The life of any paint may be divided into three stages or periods: (1) the period of storage intermediate between manufacture and application, (2) the period of application when the paint is spread out in a thin, wet film, and (3) the period of exposure covering the life of the dry paint film. Each period is characterized by certain physical properties which indicate the value of the paint. During the first period little information of value is obtainable, but even here certain defects in manufacture or material may be indicated by such phenomena as flocculation, caking, or excessive settling. It is during the second period that the really valuable physical properties, such as the wetting power or adherence to the surface, ease of application, hiding power, color, uniformity, gloss, spreading rate and rate of drying first appear. In the final stage of the life of the paint the only factors with which we are concerned are those which affect the permanence or stability of the film established as a result of the properties which appear and function during the second period. We know that all of these properties are important, but few if any can be measured with any degree of accuracy, and most of the properties are tested by methods in which the personal equation is so large that reproducible results can not be obtained. Any study of the physical properties of paints necessarily must begin with a standardization of tests and consequently our attention at present will be confined to a very few of the properties mentioned above.

The Preparation of Paint Films.—In view of the number and importance of the properties which first become evident at the time of application, it is obvious that this second stage in the life of a paint forms the logical starting point for any investigation. The physical properties which combine to determine the consistency or behavior of a paint at the time of application are of fundamental importance, but before any comparative study of a number of paints could be undertaken it was necessary to devise some reproducible method of preparing paint films. Flowing produces satisfactory results but unfortunately is limited to a very few of the thinnest paints. The ordinary methods of brushing and spraying are unsatisfactory since the resulting films are never uniform and can be duplicated only by accident. Some mechanical means therefore must be employed and as a result of some promising preliminary experiments the idea of using centrifugal force was adopted.

A number of circular glass plates furnished the standard surfaces to be covered with paint. These plates were each 25 cm. in diameter and approximately 1 cm. thick. The surfaces were ground flat and finished by fine grinding but were left unpolished, to furnish a surface to which the paints would adhere readily. In the earlier work steel plates were used interchangeably with the glass plates but were later discarded, as the glass proved to be much easier to handle and to keep clean.

The apparatus employed consists of a vertical spindle rotated by a belt connected with a variable speed motor. To the upper end of the spindle is fastened a circular wooden block to support the glass plate which is held in position by several small screw hooks at the circumference of the wooden block. The plate is brought up to constant speed and an excess of paint, previously screened through a 200-mesh sieve to insure uniformity and freedom from skins, is poured on at the center of the plate. The paint flows out, covers the surface, and the excess is thrown off. The motor is then stopped and the plate removed and allowed to dry. After the paint is dry the film thickness superior is determined by means of an Ames dial gage, reading direct to 0.01 mm. and estimating to 0.001 mm.

At any given speed the centrifugal force increases directly with the distance from the center of rotation. One would expect, therefore, that the resulting film would be thinnest at the circumference of the plate and would reach a maximum at the center. This is what usually occurs and the resulting film is generally pyramidal, although the pyramid does not extend uniformly over the entire surface. The film usually presents the appearance of a large, flat plane with a small, sharply defined pyramid at the center. In other words, starting at the circumference the film increases very gradually in thickness until a point near the center is reached. Beyond this point the film increases suddenly and markedly to a maximum value for that particular paint and speed. The pyramidal film which is characteristic of most paints, is not produced by varnishes nor by liquids, such as linseed oil. These give flat films of uniform thickness across the entire surface, in spite of the fact that the centrifugal force varies widely at different points on the plate.

The flat film characteristic of the oils and varnishes form while the plate is in motion and are not due to the action of surface tension or any other force after the plate has come to rest. This was shown by continuous whirling of a quick-drying varnish until the film was hard and dry. This dry film was perfectly flat and showed no indication of any pyramid at the center. The enamels appear to occupy an intermediate position between the flat varnish or oil films and the pyramidal paint films, some of the enamels being perfectly flat, others distinctly pyramidal.

Effect of Amount of Paint Used.—Numerous experiments performed with varying amounts of paint led to the conclusion that the film thickness is independent of the amount of paint applied. An insufficient amount of paint will cover only a portion of the surface while an excess of paint will cover the entire surface and the excess be thrown off. The resulting films in both cases are of equal thickness at corresponding points, but for the sake of convenience it is advisable always to use a slight excess of paint to insure covering of the entire surface.

Effect of Speed of Rotation.—The centrifugal force increases as the square of the angular velocity so that one would expect the film thickness to decrease as the speed increases. At speeds of 200 r. p. m. or less many paints produce films too thick to dry properly. Too high speeds cause segregation of the pigment particles and in some extreme cases a tendency to disrupt the film has appeared. A speed of 300 r. p. m. seems to be the most generally satisfactory, producing a minimum number of sandy, segregated films and a negligible number of thick wrinkled films.

Effect of Time Rotation.—The film thickness is practically independent of the time of whirling after the first short interval of time has elapsed. Under normal conditions practically all of the excess paint will be thrown off during the first half minute of whirling, after which only an occasional drop is thrown off. The time necessary to reach equilibrium, of course, varies with the speed and with the mobility of the paint; the lower the speed and the lower the mobility the greater will be the time required. Working with ordinary paints at a speed of 300 r. p. m., it was found that three minutes' whirling invariably provided a comfortable margin of safety beyond the time necessary to reach equilibrium.

The most satisfactory feature of the results obtained is the uniformity of film thickness produced at points subjected to the same forces and the agreement obtained in duplicate experiments.

Effect of Varying Composition on Paint Films.—Our next investigation was a study of the effect produced upon the life and behavior of a paint film by varying the proportions of pigment and oil in the film. For comparative purposes the films should be of equal thickness and the use of centrifugal force as previously described furnishes a convenient means for determining the film thickness which will result when any paint is spread under certain selected conditions. If several paints produce films of equal thickness when whirled at the same speed it may be assumed that those paints will produce comparable films when brushed out on test panels. The object sought was to produce a series of paints of varying oil-pigment ratios thinned with turpentine until they would spread or brush out to produce dry films of equal thickness.

Four pigments were selected for study:

(a) Basic carbonate white lead;
(b) Zinc oxide;
(c) Sixty per cent basic carbonate white lead, 40 per cent zinc oxide;
(d) Sixty per cent basic carbonate white lead, 30 per cent zinc oxide, 10 per cent asbestine.

Each pigment was ground to a paste with a normal amount of raw linseed oil. Each paste was divided into several weighed portions and varying amounts of oil were added to the different portions until the resulting series of semi-pastes or semi-paints represented a range of pigment content varying from 15 to 50 per cent by volume, the corresponding limits for the oil being 85 and 50 per cent by volume. Liquid drier was added to each semi-paint in the proportion of 5 cc. of drier to 95 cc. of oil. The various semi-paints were listed and assigned serial numbers as shown in accompanying table.

These semi-paints varied in consistency from pastes such as Nos. 8, 16, 24 and 32 to extremely thin paints such as Nos. 1 and 2. Some one mixture had to be chosen as an arbitrary standard and No. 3 was adopted, since this mixture behaved well under the brush and produced a film of satisfactory appearance and properties. The other mixtures were thinned with turpentine until they produced the same film thickness as No. 3 when whirled at the same speed. The turpentine being volatile serves merely to increase temporarily the mobility of the paints and later evaporates.

COMPOSITION OF SEMI-PAINTS AND PAINTS.

Pigment.	Semi-paint No.	Percentage by volume. Pigment.	Percentage by volume. Oil.	Volume of turpentine added to 100 cc. of Semi-paint, cc.	Paint No.
Basic carbonate white lead	1	15	85	(Discarded. Too thin)	
	2	20	80	(Discarded. Too thin)	
	3	25	75	0 (Standard)	3 a
	4	30	70	8	4 a
	5	35	65	16	5 a
	6	40	60	24	6 a
	7	45	55	32	7 a
	8	50	50	40	8 a
Zinc oxide	8 x	12.5	87.5	0 (O. K.)	8 x a
	9	15	85	10	9 a
	10	20	80	30	10 a
	11	25	75	55	11 a
	12	30	70	70	12 a
	13	35	65	80	13 a
	14	40	60	92.5	14 a
	15	45	55	95	15 a
	16	48.2	51.8	97.5	16 a
60% basic carbonate white lead 40% zinc oxide	17	15	85	(Discarded. Too thin)	
	18	20	80	0 (O. K.)	18 a
	19	25	75	20	19 a
	20	30	70	35	20 a
	21	35	65	50	21 a
	22	40	60	57.5	22 a
	23	45	55	65	23 a
	24	50	50	75	24 a
60% basic carbonate white lead 30% zinc oxide 10% asbestine	25	15	85	(Discarded. Too thin)	
	26	20	80	0 (O. K.)	26 a
	27	25	75	20	27 a
	28	30	70	35	28 a
	29	35	65	47.5	29 a
	30	40	60	57.5	30 a
	31	45	55	65	31 a
	32	50	50	75	32 a

The adjustment of the basic carbonate white lead series by the addition of turpentine was first attempted. It was found that No. 8, containing the most pigment and the least oil, required the addition of 40 cc. of turpentine to 100 cc. of oil-pigment mixture to produce a dry film of the same thickness as No. 3, the standard. The mixtures intermediate between Nos. 3 and 8 increase successively in ratio of pigment to oil so that it was natural to assume that the turpentine requirements would increase successively from zero for No. 3 to the 40 cc. required by No. 8. This proved to be a fact. Similar reasoning did not hold in the cases of zinc oxide and mixed pigments and we were forced to adopt an empirical method, adding the turpentine in 5-cc. portions until the desired film thickness was obtained. The composition of the final paints obtained by this method is also shown in the table.

This series of paints was made up, brushed out on a series of panels and the panels exposed to the weather on January 14, 1922.

The Aging of Basic Carbonate White Lead Paints Before Application.—It is generally believed that a paint resulting from the thinning or breaking up of basic carbonate white lead paste should be allowed to stand for a day or two before being used. The probable reason for the origin of this belief was found when a white lead-oil turpentine paint was used immediately after mixing, flowing the paint on a clean glass plate to form a smooth wet film. In the course of a few minutes small pits appeared on the surface of the film and gradually increased in depth and diameter. The original surface was never bared, being covered with a thin, transparent film of oil at the bottom of the pits, but the paint film was worthless, either for protection or decoration. The phenomenon appeared over and over and could not be ascribed to any fault in the preparation of the surfaces painted. The same result was obtained no matter whether the paint was applied to glass, steel or to a previously dried coat of paint.

The trouble is not connected with the rate or amount of mixing. Several paints of the same composition were stirred for variable periods, from the minimum stirring by hand necessary to insure a uniform mixture to a maximum of 70 minutes violent mechanical stirring. No appreciable difference was apparent as a result of the variable amounts of stirring, indicating that the trouble is not caused by lack of stirring. Vigorous stirring of a paint which had ceased to spot did not bring back the spotting tendency, showing that the trouble is not caused by too much stirring.

This effect evidently is produced within the paint, and a number of experiments were carried out in an attempt to locate the constituent or constituents causing the trouble. The tendency to pit appears to result whenever basic carbonite white lead and raw linseed oil are brought together. It may be modified to some extent by the composition of the vehicle but is always present.

Different samples of white lead paste of varying age and varying oil content all behaved approximately alike. The presence of liquid driers sometimes reduces the tendency but never eliminates it. The presence or absence of turpentine in the vehicle usually has no effect. The trouble does not appear when boiled linseed oil is substituted for the raw oil. Basic carbonate white lead is the only pigment which has shown this tendency; various samples of ochers, siennas, blacks and white pigments other than basic carbonate white lead all could be used immediately after mixing. Mixtures of basic carbonate white lead with other white pigments usually gave trouble when the white lead content was high but did not invariably do so.

Experiments with Oil-Pigment Mixture.—The following experiments indicate that the source of the trouble is located in the oil rather than in the pigment. An oil-pigment mixture was made up and allowed to stand several days until the pigment settled, leaving a layer of clear oil on top. This oil was separated from the pigment, paints were made up and examined for spotting, as follows:

(a) Treated oil and treated pigment;
(b) Treated oil and fresh pigment;
(c) Fresh oil and treated pigment;
(d) Fresh oil and fresh pigment.

Both paints made with fresh oil spotted readily; neither paint made with the treated oil spotted at all, showing that the troublesome constituent is located in the oil and indicating the possibility of curing the oil by agitating with basic carbonate white lead during storage prior to use.

Different samples of raw linseed oil all showed the same tendency, although it was more marked in some cases than in others. The ordinary analytical determinations furnish no explanation of the different behavior of the oils.

The presence of traces of water in the oil was considered as a possible source of the trouble. A sample of raw oil was freed from water by heating for three hours at a temperature of 105 to 110 deg. C., an atmosphere of CO^2 being maintained to prevent oxidation of the oil. Another sample of the same oil was saturated with water by adding an excess of distilled water and shaking for about 30 minutes. Some hydrolysis of the oil occurred which produced a stable, cloudy emulsion of oil and water floating on the excess of water. Portions of the water-free, water-saturated, and untreated raw oil were made into paints and the films compared. The water-free and untreated oils both spotted readily while the water-oil emulsion showed only faint traces of surface pits. A portion of the water-oil emulsion was filtered through paper, breaking up the emulsion and producing a clear oil, the water apparently being retained by the filter paper. This filtered oil produced a spotted film similar to the water-free and untreated oils and much inferior to the film produced by the oil saturated with water. It appears, therefore, that the absence of water does not remedy the tendency to spot; in fact, the presence of water may be desirable as far as the spotting tendency is concerned.

Small amounts of free mineral acids were added to portions of the raw oil and the resulting oils were made into paints. The results were indeterminate, owing to the liberation of carbon dioxide and the change in the nature of the pigment resulting from the action of the acids on the basic carbonate white lead. It is difficult to believe that this spotting tendency is due to gas bubbles, which would be the obvious result of the presence of free mineral acids. Gas bubbles would form in the body of the film and would be visible below the surface. When the gas pressure finally became great enough to disrupt the surface film the gas would escape and the paint would flow together again. What actually happens is that small pits appear first in the surface film, gradually and continually increasing in depth and diameter, which is just the reverse procedure from that shown during the formation of bubbles. No bubbles have been observed when the films spotted.

The only available samples of commercial boiled linseed oil produced good paint films, none of which showed any tendency to spot. The difference between raw and boiled oils may be due to the presence of driers in the boiled oil or to whatever changes are produced by the heat alone. Accordingly, samples of raw oil were boiled both with and without driers at 110 deg. C. and at 260 deg. C. The samples boiled at 110 deg. C. with and without driers spotted readily, and the sample boiled at 260 deg. C. without drier spotted somewhat worse than the other two, while the oil boiled at 260 deg. C. in the presence of driers did not spot. Apparently the combined action of heat and driers will cure the spotting tendency but neither one alone can accomplish the desired result.

When raw oil is used the only remedy appears to be aging. Every paint which gave a spotted film when freshly mixed gave a perfect film after standing for a while. Twenty-four hours' aging before application prevented spotting of the great majority of the paints examined and the few which still spotted slightly at the end of 24 hours produced good films at the end of an additional 24 hours. No paint has been found which exhibited this tendency 48 hours or more after mixing.

There appears to be some portion or constituent of the oil, as yet unidentified, which combines or reacts in some way with the white lead, creating forces which cause partial disruption of the film and segregation of the pigment away from the affected areas. This reaction proceeds slowly and requires a certain length of time to reach completion. The conclusion has been reached that the trouble is probably caused by the reaction with the basic carbonate white lead of some of the unsaturated bodies present in the oil. The trouble is eliminated when the compounds are saturated with the pigment during aging, or with driers during the boiling process at high temperatures. The improvement in the case of the oil-water emulsion may be due to the concentration of the troublesome constituents in the interphase of the emulsion, to some extent preventing contact with the pigment. It would be interesting to follow the effect of different methods of blowing and boiling samples of the same oil, but unfortunately equipment for these experiments is not available in this laboratory.

This phenomenon should not be confused with the defects exhibited by the type of poor paint usually classed as "runny," nor with the somewhat similar appearance occasionally encountered in commercial paints. These paints had been thoroughly aged and were of satisfactory composition as shown by the ordinary analytical determinations. It is generally believed that such unsatisfactory paints are due to improper preliminary treatment of the oils or to inadequate or improper incorporation of the constituents to form the finished paint. When the materials or treatment are at fault the resulting conditions are permanent and the properties of the paint never improve. In the case of the white lead and linseed oil the trouble is wholly temporary and will remedy itself if given time enough.

Causes of Spotting Tendency.—Summarizing these observations, it appears that the spotting tendency:

(a) Is common to all mixtures of basic carbonate white lead and raw linseed oil;

(b) Does not appear when other pigments are substituted for the basic carbonate white lead;

(c) Does not appear when other oils are substituted for raw linseed oil;

(d) Is not due to too much stirring or to lack of stirring; presence or absence of liquid driers and volatile thinners; order of mixing; presence of free fatty acids, mineral acids, or water, although any or all of the foregoing factors may at times exert a modifying influence:

(e) May be explained upon the assumption of a reaction between the basic carbonate white lead and some unidentified portion of the oil;

(f) May be eliminated by boiling the oil in the presence of driers which may convert the troublesome component to an inactive form; by treating the raw oil with basic carbonate white lead during storage prior to its use; or by aging the paint to allow the reaction to reach completion before the paint is applied.

Correction Factor of Standard Cement Samples

During the month there has arisen a question as to the clearness of the term "correction factor" as applied to corrections for No. 200 sieves and used in certificates for the same issued by the U. S. Bureau of Standards. Earlier in the year the U. S. Bureau of Public Roads of the U. S. Department of Agriculture sent out portions of a co-operative sample of Portland cement to various State laboratories for comparative tests. The results of these tests in several instances showed a lack of knowledge of the proper application of the term "correction factor" for No. 200 sieves, some using it as a multiplier and others to derive a ratio for the correction of the sieve tests. It, therefore, seems appropriate to devote a little attention to just what is meant by this factor. The "correction factor" for No. 200 sieves is either additive or subtractive, indicated by the words and signs plus (+) and minus (—). It is applied to the last operation in the sieve test, the per cent passing the sieve, and the result of the application is the true fineness of the material which has been tested. While the wording of the No. 200 sieve certificate in reference to the application of the "correction factor" seems clear, it is thought that confusion may be avoided by eliminating the word "factor." A revision of the No. 200 sieve certificate is, therefore, being considered. However, it is thought advisable before revising the certificates to make a further study of the laws governing the application of correction factors, over what ranges they are constant, and their variation with the varying degrees of fineness. Although this investigation has been delayed for some time because of the press of work in the laboratories, it is hoped to carry it to completion as soon as possible.

Reducing the Fire Risk in River Front Structures

Lessons of the Fire at Government Wharf, New Orleans, La., and Suggested Design and Construction Methods for Preventing Similar Disasters Outlined in October Proceedings of the Louisiana Engineering Society

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Within the past few months, New Orleans has been visited by three disastrous fires along its river front, each being attended by loss of life and property, the total value of the latter reaching may millions. In addition to this, these fires have interfered seriously with the business of the port and have been a serious menace to other property which, by strenuous effort and good fortune, has been saved from destruction. The seriousness of these losses, and especially the ever present danger of their repetition on even a larger scale, should furnish sufficient incentive for every citizen of New Orleans who is in any way connected with the design, construction, maintenance, use or protection of similar facilities to consider all means which may be employed to prevent their recurrence.

Engineers charged with the design and maintenance of wharves, dock sheds and similar structures are especially interested in the following features:

Suitability of various available construction materials.

Design of structural details to prevent or to retard ignition from within the structure or from outside exposures.

Design of details to prevent or retard the spread of fire from one portion of the structure to another.

Design and location of protection appliances, including water mains, sprinkler systems, hydrants, hose houses and reels, chemical extinguishers (and where oil is stored in quantities, the newer foam system for smothering oil fires).

It is possible that engineers might also devise some means of protection against the "harbor oil" menace though this is considered more as a matter to be controlled by municipal and port authorities. It is a real menace, however, which probably never will be entirely eliminated though every effort should be made to prevent the emptying of waste oil in the river as well as to prevent its deposit at points where it may add to the fire hazard. This dumping of oil is done principally at night though oil was being thrown overboard in bucketfuls from one vessel while I was engaged in taking photographs of the burned government wharf on Sept. 20.

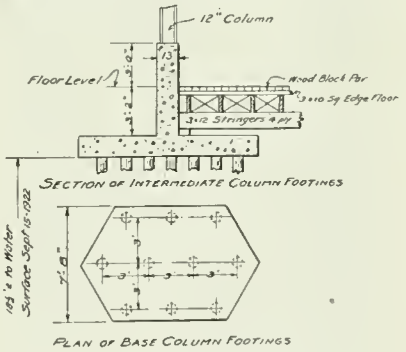
For the purpose of this paper, the fire at the Army Supply Depot will be used as an illustration. A considerable portion of the following description of the wharf and building, as well as a number of other smaller portions of this paper, are copied from an article which was contributed by the writer and was printed in the Engineering News Record in its issue of Oct. 5th. With this explanation and apology, the use of quotation marks to cover occasional repeated matter will be dispensed with.

Description of Wharf.—The burned structure was owned by the U. S. Government (having been built during 1918 and 1919 as an adjunct to the Army Supply Base) but was operated, under lease, by the Board of Port Commissioners, for commercial purposes. It extended for a distance of 2,000 ft. along the left bank of the river, with its center near the foot of Poland St. The overall width of the wharf was 171 ft., the two-story building being 140 ft. wide, the rear, or land side platform 11 ft. and the water side platform 20 ft. wide. Height of floors and other elevations are given in the following table, the elevations being referred to Cairo Datum:

Mean gulf level	20.43
Water surface at time of fire (about)	22.8
Base of fire walls	38.7
Base of concrete footings of steel columns	41.7
First floor level	46.5
Base of steel columns	49.5
Second floor level	63.5
Wall plate	75.5
Belt line tracks, rear of wharf (about)	42.5
Extreme low water (Dec. 12, 1872)	17.30
Ordinary low water	21.0
High water—1921 and 1922	40.1

This indicates an exposure of supports under fire wall, on the date of the fire, of nearly 16 ft.

It should be noted that none of the elevations shown in the above tabulation may be taken as absolute, owing to the regrettable fact that here is a lack of uniformiy among the various public engineering agencies in the assumed elevation of datum planes.



SECTION OF INTERMEDIATE COLUMN FOOTINGS

PLAN OF BASE COLUMN FOOTINGS

Fig. 1.—Details of Column Footings.

Structural Details.—The wharf and building were supported on a substructure of creosoted piles and timbers. Clusters of ten piles supported the concrete column footings which were spaced on 20 ft. centers in each direction (see Fig. 1 for details). Sash and diagonal braces were of 3 in. plank, bolted to the piles. Four ply stringers were employed, built up of 3x12 planks bolted together. Joists were also of 3x12 and square edge rough 3-in. planks were used as a subfloor. On this was placed a sand cushion for the wood block paving of the main floor. The second floor was of plank.

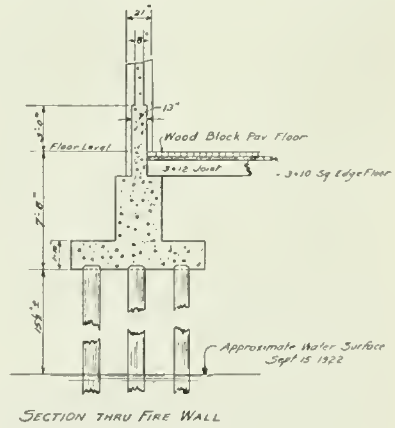
All columns, cross girders to carry the second floor and the roof framing were of structural steel, the heaviest members used being 24-in I-beams.

The roof was of pine sheathing covered by 3 ply "prepared" roofing, without gravel topping. The outside wall covering was of corrugated, galvanized iron.

Cross fire walls were constructed at intervals of 200 ft., there being nine intermediate and two end walls. These each rested on three rows of piles and were constructed as indicated by Fig. 2. As indicated in this drawing, these walls were 13 in. thick from the point support of floor joists to base of columns (3 ft. above 1st floor level) decreasing to 8 in. thick at this point excepting that at 20-ft. intervals (where the steel columns were encased within the wall) the thickness of wall was increased, resulting in a double pilaster with a total thickness of 23 in. It is apparent that the fire walls were built up to a level of the base of columns, the steel frame work then erected, followed by the pouring of the upper portion of the walls. Fire doors, of approved design, protected all openings through the fire walls. Each wall terminated in a T head which formed a 15 ft. section of the outer walls and a 15 ft. section of concrete platform was constructed at the ends of the walls to prevent communication of a fire from one section to another along the outside freight platforms.

Fire Fighting Equipment. — Recesses with concrete sides and tops were let into each of the T-heads forming a hose house, opening onto the front and rear platforms. Each hose house was equipped with a double opening hydrant, hose cart, and ample supply of hose, extra nozzles, axes and other emergency equipment. Monitors rising above the roof level were placed at each end of each of the fire walls.

The interior of the building was well supplied by 40 gal. chemical extinguishers, mounted on wheels, and 2½ gal. hand extinguishers. A complete sprinkler system was installed in both the first and second story.



SECTION THRU FIRE WALL

Steel Columns rest in wall, base of columns 3' above floor level At columns wall increases to 21" thick to encase columns

Fig. 2.—Section Through Fire Wall.

Water Supply.—Water was furnished through a connection with the municipal system with a reserve supply carried in the three emergency tanks placed on the main depot buildings. These tanks are each of 50,000 gal. capacity and they are placed at an elevation of about 100 ft. above the wharf. A 12-in. longitudinal main ran under the wharf floor, along the line estimated to be about 100 ft. from the land side. This main was fed through one 10-in. and two 12-in. cross mains leading from the city supply and from the storage tanks. All water mains under the wharf were supported by metal hangers or by wooden cross supports spiked to piles. The hangers were ¾ in. round steel supported at each end by a ⅝x3 in. lag screw set in the wooden stringers or joists.

Three tracks of the Public Belt Railway ran parallel to the wharf at the rear, all tracks being carried on a creosoted pile trestle. Floors of cars standing on these tracks were practically on a level with the lower floor of the warehouse. Cars standing on the track nearest to the warehouse cleared the platform by about 3 ft.

The only "exposures," as the term is used in fire protection parlance, consisted of the three track trestles and cars at the rear and the Desire St. shed (used by Vaccaro Bros., as a fruit wharf) which was upstream from the burned structure and separated from it by an open basin 180 feet in width along the river front.

The U. S. Weather Bureau station (located about 3 miles southwesterly) shows weather conditions during the night of the fire as follows:

Wind slightly variable in direction but from a generally northerly quarter, practically at right angles to the axis of the burned wharf. Velocity 4 to 9 miles per hour.

Light showers from 8 o'clock to 10:35, when rain ceased.

Origin and Progress of the Fire.—While the following description is stated in the form of established fact, it must be admitted that there is still a decided difference of opinion in regard to certain details and it is quite possible that some of the "facts" herein recorded may be found to be erroneous. Every effort was made, however, to secure reliable data and it is believed that so far as they effect the engineering questions involved, the statements may be accepted as correct.

The fire was first discovered at about 8:15 p. m., in a carload of burlap which stood on the track nearest to the wharf. It is probable that the fire had reached quite an advanced stage in the car of burlap before it was discovered. After giving the alarm, Government and dock employees attempted to put out the fire by the use of the hand hose outfits before described, but in a short time (probably not over 15 or 20 minutes after the fire was discovered) the water pressure dropped so low that the hose became ineffective though at the outset the force was so great that it required two men to each nozzle.

Under the influence of the northerly wind, soon augmented by the flue like effect of the hot air passing under the floor of wharf, the fire spread rapidly to all portions of the substructure. From reports of dock workers and men on the vessels on the river side, it is apparent that the draft created under the floor was so great that the fire spread for the whole width almost instantly after it had started under the windward side.

The fire communicated with goods stored on the main floor, first by passing up through the 18 in. grating protected openings provided to serve as drains when scrubbing down the floors, and later by burning through the joists and sub-floor. Several sections of the substructure were burning before the fire reached the interior of the wharf.

Behavior of Wooden Members.—All of the piling, braces, caps, joists, subfloor and block paving were of creosoted Southern pine. This material had been in place for from 3 to 3½ years and with the exception of the subfloor and paving blocks had been fully exposed to weathering for that length of time though very little of it was exposed to the direct rays of the sun.

From the appearance of piling and of timbers of considerable thickness which were exposed to intense heat (but not to direct draft) it appears that such members did not ignite readily nor did they burn to any great depth. A considerable portion of the piles which were in direct line of the draft are still standing though badly charred. These still retain from 10 to 60 per cent of their original section. Several cases were noted in which the bolts used at sway brace connections had burned out a hole large enough for the bolt and its cast iron washer to pull through the pile which was left standing. Practically all of the thinner members which were exposed to the main fire, such as bracing, floor joists, etc., were destroyed.

A search through the debris brought to light hundreds of the wooden paving blocks. Specimens which appeared to be typical of those from the landside platform (Specimen A) and others from the central part of the building (Specimen B) were selected. The condition of these specimens was as follows:

A.—Block intact, a horizontal section through the center showing original outline, slightly charred on under side and burned through for about one-fourth of depth from top. Vertical fracture shows about three-fifths of thickness of unscorched wood with evidence of cresote present. Considerable variation was noted, some blocks being more deeply charred and some in such condition that they would be suitable for relaying if turned over.

B.—This block had lost much of its section, both at ends and sides, and is charred through. Slight trace of original color of the wood. Mechanical strength below that of ordinary charcoal. There can be no doubt that many of these blocks were reduced to an ash though some charred remnants may be found under almost any portion of the building and occasional blocks were discovered which were in much better condition than the sample selected as typical.

Both specimens were taken form locations where the substructure (excepting the piles) was completely burned.

As the interior of the building was untenable long before the fire had worked above the floor, no accounts of eye witnesses of the burning of the blocks could be obtained.

Impressions Relative to Inflammability of Creosoted Member.—The impressions gained from an observation of the ruins and from conversation with competent observers, relative to the inflammability of the creosoted members are as follows:

1.—Cresote treatment, if followed by a few months of seasoning, increases the ability of wooden members to resist ignition and retards burning after ignition.

2.—Excepting where conditions are favorable for further burning (such as a strong wind and exposure to other burning members) fire in creosoted timbers of heavy section will go out even after it has made considerable headway.

3.—Continued intense heat causes cresoted materials to give off a gas which is inflammable and which may aid in the spread of fire after it has reached an advanced stage. The burning of this gas, and of the oils exuded by heated timbers, causes a more dense smoke than burning untreated timbers.

4.—The amount of oil and gas which will be given off by creosoted timber varies with the intensity and length of time of application, of the heat and inversely as the degree of seasoning.

5.—Creosote treatment does afford substantial resistance to burning in a small fire or in any fire during its early stages but may add to the danger of communication to other materials as the fire reaches a more advanced stage.

While the foregoing are given as impressions, it should be noted that the added resistance to fire afforded by a creosote treatment has been noted by other observers and established by laboratory tests.

A typical result is shown of a test described in the Proceedings of the National Fire Protection Association of 1915 (page 133). Five specimens each of untreated air seasoned and of untreated kiln-dried and seven specimens of creosoted, Southern pine were tested on an electric plate, heated to 450° C. (842° F.) In discussing this test, it is stated that: "the conclusions drawn from these preliminary determinations were that creosoted timber, after drying about six months, is much less inflammable than similar timber in an untreated condition." The creosoted test pieces made a more favorable showing both as to initial ignition and loss of section during a given period of application of the heat.

While certain valuable data may be secured from examinations such as have been made of burned structures and from small scale laboratory tests, the subject is of too great importance to justify the engineers and the commercial interests involved in forming conclusions from such data. Nothing but large scale tests, conducted as nearly as possible under conditions parallel to those existing on our river front, should suffice as a guide to future practice. These tests, financed jointly by commercial and public organizations and supervised by a special committee, the personnel of which would insure unbiased action, could be arranged easily and would be of incalculable benefit to this port and to the whole country. It is urgently recommended that such a test, or series of tests, be made.

Behavior of Concrete.—As will be noted from the general description of the building, the use of concrete was confined to the column footings and to the fire breaks. From the nature of the stores burned and of the substructure, it is certain that comparatively high temperatures were reached in certain sections of the building but there is no evidence of the excessively high degrees of heat which have been reached in such conflagrations as the Baltimore and the San Francisco fires.

Severe spawling of concrete was noted, especially at the corners of the concrete footings where they were exposed to the maximum heat. In a number of instances, exposed corner reinforcing rods were noted but in no case did the failure of concrete appear to be the result of weakening by disintegration. Reinforcing rods were exposed only in such members as had been subjected to severe treatment such as falling (as a result of failure of their supports) or by receiving blows or twists from falling steel members. Corner reinforcing rods of column footings were covered by 4 in. of concrete. Examination of concrete exposed to maximum temperatures showed signs of disintegration (and frequently spawling) to a depth of nearly 2 in. on flat surfaces and as much as 4 or 5 in. on right angle corners. After knocking off that portion which had become softened by the heat (or heat and water) the inner portion was found to be dense, hard and of a uniform texture. Small gravel was used as the coarse aggregate. No evidence could be found, even in the most exposed samples, of a splitting or disintegration of the individual pebbles forming the coarse aggregate. The concrete had the appearance of a 1:2½:4 mixture. In each case noted of broken concrete footings, the fracture was at the bottom of the anchor bolts. Two bolts were used for each column. These were ⅞-in.x18-in. and they were run through an angle bar (estimated to be about 3x3x12 in.) which served as a washer at the lower end. It was on the plane of this angle bar anchor that the fracture occurred.

Several portions of fire walls are still standing though with the exception of short portions at the T-heads, these are invariably broken off at the elevation of base of columns, 3 ft. above floor level. From an examination of the ruins, it is apparent that those walls which did not fall from burning of pile supports were pulled over by the failure of the structural steel frame work with which they were incorporated. This theory is supported by testimony of observers. It does not appear probable that walls constructed as described could be depended upon to remain standing through the burning of a single intermediate section containing a reasonable amount of inflammable stores, even though the fire were kept from the substructure.

Behavior of Structural Steel.—With the exception of the cross rows of columns which were incased in the eleven fire walls, no steel frame members were covered or in any way protected from the heat of the burning building and contents, the result being that there is hardly a piece of structural steel of any importance which is not badly bent and twisted.

From an examination of the columns, it appears as though they had failed by being pulled over by other members rather than by weakening under heat and crushing down from their loads. A sharp bend, through 150 to 180 degrees, was noted in the most of the columns, at a point only about one foot above the base plate. This is shown plainly in the accompanying photographs. Practically no "crumpling" of compression members was noted and no fusion of heavy sections. Sheet metal, wire and thin sections of pipe were found which had partially melted.

Automatic Sprinklers.—At an early stage of the fire, sufficient heat reached the first floor compartments to set off the automatic sprinkler system though owing to the fact that at that time, fire was burning only under the floor, it is not probable that the sprinkler system was an important factor in delaying the progress of the fire. Witnesses have stated that during the later stages of the fire, the sprinkler system was not in operation. It is probable that it ceased to function at the time of the drop in pressure as referred to below.

Chemical Appliances.—No use was made of these as the fire made such rapid progress, after its discovery, that they could not be brought into action to advantage.

Water Mains and Hose Connections.—When the fire was first discovered, several lines of hose were connected to the nearest hydrants and an effort was made to extinguish the fire in the burning car of burlap. As already stated, the pressure was good when the hose was first put into action, but in only a short time after the hydrant valves were opened, the pressure dropped so low that the streams were practically worthless. The most reasonable theory regarding this sudden drop in pressure is that some of the stirrup hangers supporting the water mains failed and let the heavy pipe fall and break. A number of these hangers are still in evidence, hanging from one end, the lag screw fastening at the opposite end having come loose, permitting the hanger to hinge on the remaining single support. If the supply lines had remained intact, it is probable that the sprinkler and hydrant systems would have functioned properly, though it is not reasonable to suppose that they would have had any material effect on the final outcome as the fire appears to have reached a stage at which it could not be controlled before it broke through the first floor. With the floor intact, neither the sprinkler system nor the hand hose could have any appreciable effect on a fire in the substructure.

Suggestive Preventive Methods.—In considering the disastrous fires of the past few years along the New Orleans river front, one's mind naturally turns to concrete as a more suitable construction material on account of its resistance to decay and to fire and it is probable that this material could be employed to advantage in certain cases though under present conditions, it can not be considered for the great bulk of our dock and wharf construction for the following reasons:

1.—High first cost as compared with other available materials.

2.—Lack of flexibility in adapting facilities to changing business.

3.—Heavier dead loads to be carried on the river bank where foundation conditions are at their worst.

4.—Greater resulting damage to the structure from minor settling which would not be serious in case of timber construction.

5.—Possibility of necessity to retreat from certain sections of the river front due to cutting in of the banks. This may occur even when mattress protection is provided. In case of concrete structures, the original investment practically would be a total loss.

In the light of the foregoing and of the general knowledge of the unsuitability of steel (regardless of first cost) for substructure works subject to the alternate action of river water, silt, and air, it would appear that the bulk of the river front structures of the future will be designed to rest on wooden supports, protection against decay being provided by creosote treatment until such a time as some other method is discovered which will give equal lasting qualities, and at the same time, bring about a decrease in the fire hazard.

Precautionary Measures Suggested by New Orleans Fire.—Recognizing this necessity of the continued use of timber substructures, the following precautionary measures are suggested by the destruction of the Government wharf though many of these are so obvious as to hardly require mentioning:

Substituing, so far as possible, a slow burning mill type of construction for the light sections now commonly used in bracing.

Fire proof or fire resisting roof covering.

Construction of a longitudinal fire wall from low water to first floor level, to cut off draft.

Construction of cross fire walls at proper intervals, from low water level to above the roof line.

Design of all fire walls so that their integrity may not be affected by the burning or the failure of any or all of the other portions of the structure. (This probably will require practically complete isolation of the walls, so far as any substantial connections are concerned, from the frame work of the structure.)

Extension of automatic sprinkler systems to afford protection to substructures.

"Inverted Monitors," controlled from main floor or from some distant point, to reach an interior fire in the substructure.

Placing of all important water lines in such a position and with such supports and protection that they will continue to function under all conditions, so long as the main supply of water continues.

It is also suggested that consideration be given to a design which will provide more open spaces in the substructure for fire streams. The use of fewer brace timbers of heavier section, as above recommended, will be of assistance but it is possible that other improvements may be made to facilitate reaching a substructure fire from a hose held at a reasonable distance.

As corollaries to the foregoing may be mentioned the necessity for more well paved streets which will permit the prompt assembling of fire fighting apparatus at any point on the river front, provision of more floating fire fighting equipment, the rigid control of the "harbor oil" menace, special, high duty fire pumps at important structures, special water mains adjacent to wharves, maintenance of permanent "hose tunnels" under tracks at the rear of wharves so that cars can be moved without interruption to the fire department, drastic control of unnecessary vehicles and persons in the vicinity of a fire, severe penalties for dumping oil in the river and provision of an ample number of well paved cross avenues of approach to all exposures to permit the prompt collection of municipal fire apparatus.

In considering the foregoing suggested means for fire control, it must not be assumed that all can be undertaken without introducing complications other than additional expense. To illustrate, cross fire walls built down to low water level, will act as baffles to the river current, causing excessive deposits of silt at some points and possibly causing dangerous scour in other locations. An annual deposit of mud may not be as serious as an occasional conflagration but it presents a serious engineering problem which must be taken into account in the design of our river structures. High water and silt also may make it impracticable to use the "inverted monitors" suggested, at least in some localities or under certain conditions. As a matter of fact, practically any departure from established practice will bring in new complications and the best methods can be evolved only by a careful balancing of one advantage against another, and this must be done by men who are equipped properly to consider all the points involved.

Influence of Mechanical Equipment of a Building on Its Design

How the Structural Design of Office Buildings, Hotels, Apartment Houses, Etc., Is Influenced by Considerations of the Various Utilities Required for Such Buildings Described in Paper Presented Before Western Society of Engineers.

By H. L. CLUTE,
Chief Engineer, Arcade Heating Co., Chicago.

Mechanical equipment of a building is that part which furnishes such utilities as water, gas, electricity, steam, conveyance, ventilation and refrigeration. In preparing the preliminary and structural design of the building it is necessary to have a general conception of the equipment to be provided, or when too late it may be found difficult to make suitable provision and arrangement.

Equipment Required for Buildings.—Three classes of equipment are practically common to all buildings: plumbing, electric wiring and steam. Plumbing includes drainage, water supply, gas and often vacuum cleaning. Wiring is for light, power, telephones, signal system, clock system, telautograph and special purposes. Six semi-common classes are elevators, ventilation, electric generation, refrigeration, pneumatic tubes and sprinkler system. Special installations are required to serve hotel kitchens and laundries, theater stages and similar cases. Each installation may be divided into three classes: Apparatus, conductors and accessories.

To illustrate the complexity of the equipment, the water installation may include the following: Two mains for cold water (at city pressure and high pressure); two hot water mains each with supply and circulation return systems; a main and return for drinking water; brine supply and return mains, and high and low level drainage and storm water mains. Steam distribution may include high, medium and low pressure service, each with supply, return and drip mains. In a typical example there may be thirty systems of horizontal pipe mains each with five to ten risers or vertical lines through the building, and each riser with four to forty branches. These mains are at different levels, with risers extending either upward or downward. Interspersed with these pipes will be from five to twenty duct lines, with branches, pneumatic tubes and electric feeders.

Structural provisions for such equipment include ample floor area for machinery and apparatus, continuous horizontal and vertical spaces for mains and risers, space for offset for branches, and facilities for convenient operation and maintenance. In the ideal conditions all the mains would have the shortest possible leads from producing apparatus to utilizing apparatus, but paralleling the main axes of the building. But in the actual condition the equipment is twisted and distorted to keep it out of the way and out of sight. This arrangement of the equipment to meet actual conditions with efficiency and economy is sometimes one of the principal problems of the mechanical engineer.

Piping and Basement Girders.—Piping is grouped usually at basement ceilings more than at any other place, and here trouble is caused by deep beams and girders. In general the profile of the main must be a straight line with only a slight inclination from the horizontal. For this reason the entire main must be below the bottom of the deepest girder, except when some special provision is made. One building has most of the girders 26 in. deep and some 32 in. deep. As the mains must be below the latter, this brings them far below the ceiling and makes an unsightly arrangement.

This problem is one for the structural engineer. Of course the economical section of a girder is a deep one. To provide the necessary strength by increasing the width of girder instead of the depth in order to maintain a uniform depth would involve extra expense. But in certain cases this construction expense would be warranted by the saving in expense for mechanical installations and by the greater convenience and reliability in the operation of the mechanical plant. Pipes are sometimes laid through holes in the center of steel girders, but with reinforced concrete there would be the liability of interference with the reinforcing bars, especially where the girders are of varying depths.

Pipes and Floor Framing.—In the upper part of the building, pipe mains are laid usually above suspended ceilings, but here also the depth of beams and girders is a factor. In some cases a certain depth of furring has been assumed below the ceiling panel and is found to be insufficient for the piping. Then some method of increasing the depth must be found. Sometimes the pipes are carried down and around in cornices and false beams across the panels. This may be necessary but is objectionable in requiring an excessive number of turns or bends in the piping. Where a floor filling of not less than 5 in. depth is available certain mains may be laid in this fill.

A double floor at some point in the height of the building is very desirable, especially in hotel buildings where there are a certain number of special floors in the lower portion and typical or uniform floors above. I believe that in time every hotel building will be designed with a double floor construction above the special floor and below the typical floors, because all of the pipes and risers coming down the upper part of the interior of the building must be disposed of. They must be offset individually and carried down columns and in partitions and special places with various crooks and turns, or they must be collected together at mains in a floor space below the typical floors. To permit free access this space should be at least 3 ft. high.

One of these floors is the main load-bearing floor and the other is an auxiliary floor of short spans, either suspended from the main or carried above it on struts. The tendency is to place the auxiliary floor below the main floor, with the idea that all the deep beams and girders and trusses may be carried in this space and leave a flat ceiling below, whereas, if the main floor were below and the auxiliary floor above those deep beams and girders would be exposed on the ceiling. This is a mistake. As stated in connection with basement mains, those beams and girders will not permit the passage of pipes, so the depth of the pipe space should be the required amount below these beams, except that under the beams it may be reduced and workmen may crawl under beams and find a working space in the panels. In general it is best to place the working floor below and the auxiliary floor above, as the space between the girders will then be available to add to the height of ceilings in the rooms below.

A pipe shaft of ample size for riser trunks should be provided. A width of 3½ ft. is generally sufficient if the length is great enough to accommodate all the pipes in one layer. This is usually placed alongside of the smokestack, and a good arrangement is to use a beam or girder at the side of the smokestack for a walkway in the shaft, building the shaft of sufficient additional width to place the pipes.

Providing for Cables and Steam and Plumbing Risers.—Electric cables and feeders are carried up through the building at the centers of approximately equal areas, so that the distances from the cable shafts to the sides of these areas will be not over about 80 ft. If the area of the building is divided into as many units roughly of that size as required, and a cable shaft provided in each one it is a very adequate provision. It is seldom the case that the cable shaft is carried up continuously from the basement or lowest floor through the building, but it should be built in this way.

Steam risers are usually near the outside walls and plumbing risers at the interior of the building. The former may be furred in with the columns or carried up in chases. With skeleton construction it is usually difficult to provide chases, but some structural engineers are using construction in which the spandrel beam is 4 in. thinner than the thickness of the wall, the inside face of the beam being set back 4 in. from the inside face of the wall. This permits of carrying up a chase through the skeleton framing and gives an excellent opportunity to conceal the steam risers. Many buildings of the better class are now having these pipes concealed.

Interior risers are placed usually in shafts large enough to give working space for a man in maintenance and repair work. A width of 28 in. is about the minimum for a plumbing shaft. Sometimes these shafts are made continuous, or without the floor fill at each floor, and are then used as the exhaust shafts for the toilet rooms. If the floor is open, steel doors are required for access. That is fireproof construction. If they are closed at each floor ordinary wood panels may be provided. If they are left open the entire area has to be framed, whereas with the closed shaft the pipes may be carried up in sleeves between the reinforcing rods. It is always a question as to which type is best.

If the pipes or risers are furnished in special non-accessible shafts they are either at the columns or in such special locations as may be found here and there. If they are at the columns there is always the question of space required; in addition to the amount required by the pipes there is always a beam carried out from the center of the column, leaving the only available space at one side of this beam. It would be an advantage if there could be some way of designing twin beams where there are a number of shafts of this kind, especially in office buildings. That is, beams side by side, so that the extra space inclosed with the columns would be entirely utilized for pipes. This plan would add very little to the size of the column. Where the pipes are placed in various shafts wherever it may be convenient, no structural provisions are necessary.

Elevators.—With electric elevators the machines are located usually over the shafts. Beam framing at the floors carries the guides and must be designed for vertical loads imposed by the emergency brakes gripping the guides. Pits require a depth of 3½ to 4 ft. for spring buffers or 6 to 8 ft. for oil buffers and 9 ft. for compensating cables. In fact, elevator manufacturers are always asking for deeper pits. This involves drainage systems, as the pits are rarely watertight.

Providing for the Boilers.—Space provided for the boilers is found frequently to be inadequate for proper boiler capacity. Two boilers are preferable to one of equal capacity in order to provide for cleaning and reserve. Three boilers are preferable to two for plants of over 15,000 sq. ft. of radiation. Headroom is often insufficient owing to a desire to limit the depth of excavation, but there should be ample space over the boiler to give free access for inspection of safety valves, automatic checks, main valve and other accessories. For cast iron, return tubular and water-tube boilers the minimum headroom may be taken as 9, 15 and 28 ft. respectively, although some water-tube boilers require 32 ft. and some may be as low as 22 ft. Thus the type and size of boiler are factors in the building design.

Space must be provided for access to all sides of the boiler and for a firing floor in front. This latter may be from 5 to 10 ft., the latter being sufficient for withdrawing a mechanical stoker. For protection of the floor above the boiler room, an insulated ceiling is preferable to air circulation in the space over the boilers. Where coal is fed by gravity from a bunker to the mechanical stokers the minimum height from boiler-room floor to bottom of bunker will be about 12 ft. Allowing a 40 deg. slope for the bunker bottom, this gravity feed system will require a basement or sub-basement height of about 30 ft. When this is not practicable, the main bunker may be on the boiler room floor with a conveyor carrying the coal to an auxiliary bunker which feeds the stokers.

Smokestack and Engines.—The area provided for this will depend upon the boiler capacity together with the thickness of insulation and the 4 in. clearance space required by the city ordinance. Since its height varies with expansion and contraction it must be supported at one point, either on a special foundation or on a girder framing in the superstructure. The latter case requires the special attention of the structural engineer.

Where engines and generators are installed a height of 15 ft. will usually be sufficient to provide space for the large amount of piping that must be placed along the ceiling. Engine foundations must not be in contact with column foundations or floors, a joint filled with elastic packing being used in the floor.

House Tanks.—Every building of the class noted requires house tanks sufficient for 20 to 60-minute supply in emergencies. One hotel has two 10,000-gal. gravity tanks in the roof pent house for domestic supply. Other buildings have two 4,000-gal. tanks. With two tanks one can be cleaned while the other is in use. To provide support of such tanks may involve special structural design.

Air Conditioners.—These are often required in connection with the supply system of ventilating equipment and should be placed as nearly as possible in the direct line of travel from the intake to the ventilated room. The apparatus includes a fan, motor, air-washer and heaters, requiring usually a length of 26 ft. For upper floors, the conditioners may be placed in an interior room which is made available by leading to it an intake duct over the ceiling. A good location in a large building is behind the elevators, the rear wall of the elevator shaft being set back far enough to accommodate the conditioner units, with direct intake through the wall to the unit.

Tests to Determine Practicability of Requirements in Concrete Specifications of Joint Committee

The Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, consisting of representatives of the American Society of Civil Engineers, the American Railway Engineering Association, American Concrete Institute, Portland Cement Association and the American Society for Testing Materials, has accepted a proposal of a committee of contractors representing the Associated General Contractors of America that field and laboratory tests be conducted to determine the practicability of the recommendations of the Joint Committee in its Tentative Specifications for Concrete and Reinforced Concrete published in the American Society for Testing Materials Proceedings for 1921, especially in so far as they relate to control of the quality of concrete produced under field conditions. It is at present planned to conduct the tests in conjunction with the construction of a reinforced concrete building in the New York City district, with the possibility eventually of making similar tests on buildings in other cities. The Joint Committee, without expense to itself, will have advisory supervision of the tests under the auspices of a committee of contractors; it will approve the program of tests and the personnel of those who are to supervise and make the tests.

Although final plans have not yet been approved, it is contemplated to divide the tests broadly into field tests and auxiliary and laboratory tests. The field tests will be designed to establish (1) uniformity of workability or consistency of concrete throughout the work, (2) uniformity of the strength of concrete obtained throughout the work, and (3) relation of the strength of field test pieces to the strength of concrete in the structure. The auxiliary and laboratory tests are divided into four series: (1) the relation of strength of field-made test pieces to theoretical strength of mixtures used; (2) comparison of strength of field-made test pieces with laboratory test pieces; (3) relative value of cores of different diameters and heights, and (4) comparative tests of different brands of cement used.

This investigation, according to the current Bulletin of an American Society for Testing Material marks an important step in the study of concrete and reinforced concrete, which, if carried out on the comprehensive scale planned will undoubtedly contribute information of much value for consideration in the further development of these specifications.

To Erect 1114-ft. Span Suspension Bridge in Brazil.—A combined railway and highway suspension bridge of 1114-ft. span is to be built by the state of Santa Catharina, Brazil, to connect the island of Florianopolis with the continent. The contract has been awarded to Byington and Sundstrom of São Paulo, Brazil. The American Bridge Co. is subcontractor for the steelwork. H. D. Robinson and D. B. Steinman of New York are the consulting engineers on the design and construction; with them is associated L. N. Gross as consulting engineer on the erection. The work will include 1660 ft. of approach spans. The total estimated cost is about $2,000,000.

1923 Meeting of American Society for Testing Materials.—The Executive Committee of the American Society for Testing Materials has voted to hold the 1923 Annual Meeting of the Society at Atlantic City in the latter half of June, provided satisfactory arrangements can be made for the meeting. Two dates of meeting are tentatively under consideration: 1. During the last week of June, i. e., June 25-29. 2. Immediately following the meeting in Atlantic City of the American Railway Association—which is customarily held from Thursday to Wednesday about the middle of June.

Application of Welding in Building up Cable Clamps For Suspension Bridge

When the new 1,145-ft. long Rondout Creek suspension bridge (see Engineering and Contracting, May 24, 1922), which was recently placed in service near Kingston, N. Y., was being built it was found that the cast steel cable clamps by means of which the vertical cables were suspended from the suspension cables provided for only one flange to hold the vertical cable from side-slipping off the clamp shoulder and that an additional flange was needed on the opposite side of the shoulder. As the builders were in a rush, it was decided instead of waiting for new clamps to be cast to weld this additional lug to each of the 114 clamps at a local foundry by means of Thermit welding.

The Rondout Creek Bridge, Kingston, N. Y.; Main Span 705 ft.; Shore Spans 176 ft. Each.

In preparing for the welding operations, a wooden pattern was first made of the half clamp to be welded. A wooden lug pattern for the Thermit steel flange was doweled to the pattern by means of two holes drilled into the pattern A three-sided wooden box, hinged at one corner, was then placed with its open side against the pattern, clamped to the pattern and rammed with molding material. The usual wooden riser and pouring gate patterns were inserted against the lug pattern. No preheating gate pattern was inserted as the preheating was executed in a different manner, from usual, as explained later. When the ramming was completed and the molding material rammed up flush with the top of the mold box, the riser and pouring gate patterns were removed, a plate placed over the mold; the mold, casting pattern and plate inverted and the mold box and pattern removed from the mold, which now rested on the plate.

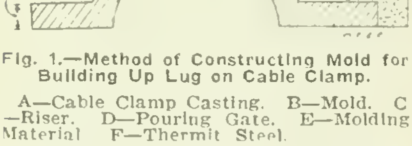


Fig. 1.—Method of Constructing Mold for Building Up Lug on Cable Clamp.

A—Cable Clamp Casting. B—Mold. C—Riser. D—Pouring Gate. E—Molding Material F—Thermit Steel.

The mold was next baked in an oven. In the meanwhile, the part of the casting to be welded was preheated over a blacksmith forge to a temperature suitable for welding. When both the operations of baking the mold and preheating the casting were completed, the baked mold was applied to the casting in the position shown in Fig. 1 and the Thermit steel poured into the mold in the usual manner, using 10 lb. of Thermit for each weld.

Much time was saved by preparing the molds for baking in close succession by applying the same mold box to the same pattern just as soon as the former was removed from one unbaked mold; also by preheating the castings successively while the baking of the molds was taking place. In this manner an average of about 25 welds per day were made.

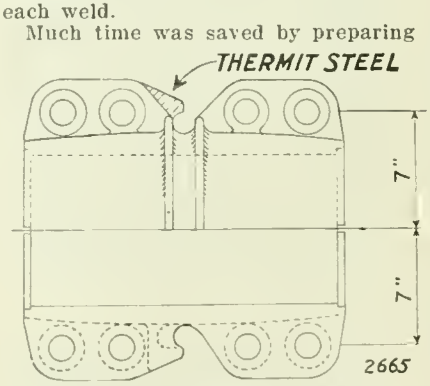


Fig. 2.—Cable Clamp and Part Built Up by Means of Thermit Weld.

Scientific Research in United States

American industry is spending about $70,000,000 annually on scientific research, according to the Fabricated Production Department of the Chamber of Commerce of the United States.

About one-half of this sum is spent by American manufacturers in the conduct of laboratory research, while the remainder is expended in experimental and development work in plants, the department points out in a bulletin on research.

As a result of scientific research work, it is explained by the department, approximately one-half billion dollars is being saved annually by industry in this country.

"The value of scientific research both from an economic and industrial standpoint," the department says, "has never been so fully appreciated as at the present time. The problems of the recent war forced science and its research activities to the front in all civilized countries. It is now realized by leading manufacturers that scientific investigation is a necessary adjunct to efficient co-operation. A utilization of the scientific knowledge now available, and a sympathetic co-operation in the free interchange of such information will lead to the adoption of improved manufacturing processes and do much to obviate the danger of ignorant, destructive competition. The realization of this fact is shown by the 500 or more firms now maintaining laboratories for industrial research.

"It is not surprising, therefore, that a continually increasing number of trade associations are realizing the value of research as one of their most constructive activities. Of the 65 to 70 associations now engaged in this work to whom a recent inquiry was sent by the Fabricated Production Department, 33 gave specific replies, indicating that 8 were conducting their research independently, and 25 were acting in co-operation with some other agency. The general leaning is toward the scientific aspect of research work. Nineteen trade associations are engaged exclusively in that class, three in the general problem class, while eleven give attention to both types of problems."

Personals.

H. D. Robinson and D. B. Steinman, 25 Church St., New York City, have been retained to act jointly as consulting engineers on the design and construction of a suspension bridge of 1,114-foot span at Florianopolis, Brazil. This will be the longest span in South America. The bridge will carry highway, electric railway and aqueduct, and will have 1,660 feet of approach spans. The estimated cost is $2,000,000. With Messrs. Robinson and Steinman is associated L. N Gross as consulting engineer on erection.

Kenneth C. Grant and Herbert A. Hamm have organized the firm of Hamm & Grant, Inc., designing and constructing engineers, with offices at 607 Ferguson building Los Angeles, Calif Mr Hamm has been engaged for the past ten years in the design and construction of packing, pre-cooling and Industrial buildings in Southern California, with offices in the Central building, Pasadena. Mr. Grant, since leaving the construction division of the army at the close of the war, has been vice-president of Frank Hill Smith, Inc., industrial engineers, of Dayton, O., and New York City. The new firm will specialize in the design and construction of industrial and mercantile buildings, including packing, pre-cooling and cold storage warehouses.

Otto M. Olsen, a post-graduate student at Carnegie Institute of Technology Pittsburgh, has been awarded the John Stewardson memorial scholarship in architecture for 1922. The scholarship, valued at $1,000, is a memorial established on the basis of a fund donated by John Stewardson, noted architect of Philadelphia, who died 23 years ago. Candidates are restricted to architects, 22 to 30 years of age, who have completed at least one year's office experience and two years in an approved school of architecture, and must have studied or practiced architecture in the state of Pennsylvania for the period of at least one year immediately preceding the scholarship award. The scholarship includes a year's travel in Italy, France, Greece and Spain.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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Engineering Salesmen

Editorial in Engineering Review, London.

With the demand for engineering jobs far in excess of the supply, it may seem absurd to suggest that engineering employers cannot find all the men they want. Nevertheless, it is true that really efficient engineering salesmen are still scarce. Good salesmen of any kind are, of course, not plentiful, since the elements of personality which go to make a popular bagman are numerous and not necessarily related to each other. But for every ten men who can make a decent success on the road with some nondescript article of commerce, there is perhaps only one engineer-trained man who can contrive to sell the article he helps to produce. This state of affairs has existed so long that one fails to understand why no steps have been taken to remedy it. The usual practice is for executive engineers to drift on to the sales side. A certain degree of selection is put into operation, but there is practically nothing in the way of systematic training. Men who "seem likely" are picked out and put on the road—more or less to take their chance of proving themselves. As alternatives to such a haphazard system two courses might be suggested. One is to make the selection from the staff at an earlier age than is customary, and to plan out a course which will make the embryo salesman familiar with every aspect of the job he has to tackle. The other is to recruit men from outside—men with the essentials of personality and with a good general and scientific education. They are to be regarded as the raw material of engineer salesmen. By giving them a two or three months' intimate acquaintance with each section of the works and offices, they will gain a broader view of the proposition than is likely to be secured by a man who has spent all his time in one section. Such a training, coupled with a close and as far as possible dispassionate study of rival products, will enable a man to approach prospective buyers with confidence. Shortly after the Armistice a similar course was adopted on an intensive basis by a leading engineering firm; the results were so satisfactory that the same principle might well be applied under the less strenuous conditions of demand now prevailing.

Chlorination of Water of Dissimilar Character

Editorial in Municipal Engineering and The Sanitary Record, London.

The purification of the water supply of London provides problems of absorbing interest, and much valuable data is being accumulated on the subject of chlorination under widely differing circumstances arising from the treatment of river water from the Thames, the New River, and Chelsea filtered water, and deep well water from the chalk at Deptford. In treating river water, Sir Alexander Houston has demonstrated that from the bacteriological standpoint chlorination succeeds considerably better than storage on the average, and is nearly seven times superior during the winter months, when both the river water and the stored water give the least satisfactory results. Chlorination does not prevent the development of algal and other growths in the reservoirs, but it has a retarding influence. The inhibitory effect of chlorine wears off, however, and if the water is stored long enough and the reservoir is infected from new or old growths, a further development may take place. In the case of the New River water the critical period is from November to January, possibly owing to the comparative absence of algal and other growths in the water during these months, which tends to the lack of a protective skin on the surface of the sand, and renders the filters permeable to the passage of microbes. The whole object of chlorination of this water is to wipe out these periodic relatively unsatisfactory results. The water is chlorinated lightly in advance of the arrival of turbid water, and as the turbidity increases the dose is raised until it reaches a maximum (say, 1 in 2 millions), and at this stage potassium permanganate (2 lb. to 8 lb. per million gallons) is added as well to prevent the possibility of taste troubles arising. As the water improves the dose is diminished gradually to as little as 1 in 5 millions. Lower down the stream there is a SO_2 de-chlorinating plant, which is only used when the dose of chlorine is at a maximum and the water exceptionally cold. Having regard to the fact that for three years no taste troubles have arisen and the bacteriological results have been of a most satisfactory character, it may be said that this particular problem is now solved. At Deptford experience is obtained in the treatment of a very clear well water, with very little oxidizable matter. The method adopted is super-chlorination (dose, 1 in 1 million) and de-chlorination with a solution of sulphurous acid gas, and has proved eminently satisfactory.

Activated Sludge Experiments at Glasgow

Editorial in The Surveyor, London.

Although various experimental works are in operation wherein the methods of elevated sludge treatment are being tried and sometimes compared, reports and definite figures are very slow in making their appearance. Certain results are sufficiently obvious in various places, but it is impossible to deal with these until results are published. Mr. F. W. Harris, corporation chemist and city analyst of Glasgow, has written a very interesting and important paper, which was presented at the annual congress of the Incorporated Sanitary Association of Scotland. In this paper reference is made to experimental work carried out at Shieldhall with mechanical agitation and compressed air. Unfortunately Mr. Harris has given the results very briefly. Thus it is possible to come to wrong conclusions. Taking the figures and results as they stand, certain deductions may be made.

It is to be noted that Mr. Harris gives the aëration period as three hours. Thus, allowing for a volume of 25 per cent of returned sludge and taking the capacity of the aëration tank as stated at 80,000 gal., it appears that a volume of 480,000 gal. per day could be treated by the experimental plant at Shieldhall. Mr. Harris gives the horse-power for operating the paddles in the tank as 30, which apparently will therefore treat 480,000 gal. of sewage per day. This, however, is not quite clear, because the aëration period with mechanical agitation is nearly double that required with diffused air, and the volume which could be treated in the tank would, on this reckoning, be 240,000 gal. per day. However, taking the 480,000 gal. at 30-h.p. the horsepower per million gallons would be 62½. The Shieldhall sewage is apparently a light sewage comparable to that of Worcester, where the horsepower per million gallons is 16. This appears to show that here the mechanical agitation process takes about four times the horse-power required by diffused air when testing a similar domestic sewage.

The running cost at Sheffield is taken as £3 10s. ($14.78) per million gallons, but in this case a great proportion of the sludge is intercepted by preliminary settlement, and it is found that by reducing the amount of organic matter in the aëration tank the oxygen demand is greatly reduced, hence the aëration required is greatly reduced also. This is one important reason, which should not be overlooked, why the Sheffield plant requires so small a horse-power compared with the figure at Glasgow. There is another reason, for, as was shown by Mr. George H. W. Lucas recently in the official journal of the Canadian Institute of Chemistry, investigations have proved that the iron content of sewage in the activated sludge process affects the color, flocking and settling of the various sludges which are formed in activated sludge plants. Mr. Lucas' results have been confirmed at New Britain in the United States, where it was found that ½ cu. ft. of air would do the work of 1½ cu. ft. of air required at Milwaukee, where no iron was present in the sewage. Thus it does not appear fair to the diffused air system to compare the Sheffield costs with those of Worcester. If 62½-h.p. is needed per million gallons of sewage at Glasgow against 20-h.p. needed at Sheffield it follows that the cost of treating the Glasgow sewage must be at least three times the figure given by Mr. Haworth for treating the Sheffield sewage. It is to be regretted that the paper did not give the comparative figure of working in greater detail. The experiments described are of great importance. As far as can be gathered from these and other works where similar trials are being made, the presence or absence of iron in the sludge, and of precipitation tanks, is a most important factor.

The Strength of Railway Bridges

Editorial in The Railway Engineer, London.

Among the subjects discussed before the Engineering Section of the British Association this year was one of very great importance to railway maintenance engineers and to structural engineers generally, not only in this country, but throughout the world—the subject, namely, of the strength of railway bridges. Three papers dealt with this topic from different points of view; two of them, by Messrs. A. C. Cookson and J. S. Nicholas, and by Mr. Conrad Gribble, respectively, and the third, by Mr. J. S. Wilson and Professor J. B. Haigh.

Messrs. Cookson and Nicholas, in their joint paper, take up the challenge which they consider was thrown down in the report issued last year on the impact tests carried out for the Ministry of Transport, and, after subjecting the conclusions arrived at therein to a severe critical examination, suggest that these are not correct interpretations of the observations upon which they are based. In their opinion, these and many other experiments prove that railway bridgework in Great Britain is much stronger than is generally believed, and they consider that the only reliable criterion, after all, is the practical experience of maintenance engineers of the strength and endurance of existing bridges, which they illustrate by reference to Great Western Railway practice. While thus strongly supporting what may fairly be called the empirical point of view, the authors nevertheless agree with Mr. Gribble, who, in dealing with present-day problems and tendencies in railway bridge design, emphasizes the need for further research work, and advocates in particular the testing to destruction of full-size bridges removed from service. He is of opinion that railway engineers would perhaps have more confidence in the results of a few such tests than in many stress records as usually obtained. The memoir presented by Mr. Wilson and Professor Haigh differs in character from the two papers above referred to, and confines itself to the definite task of describing the methods of setting forth the results of a series of experiments carried out by the authors to determine the influence of rivet holes in plates upon the strength of the structures of which they form part. The paper is indeed an example of the practical experimental work which it is generally admitted, and which this discussion only further demonstrates, needs to be carried out in this field of structural design.

Controversy on the subject of bridge design is, of course, far from new, and in engineering debates, both before and since the days of Sir Benjamin Baker, the two schools of thought referred to by the authors of the first paper, as well as others, have time and again fought out their differences. Whether indeed the "Pencoyd" formula is insufficient; whether the Ministry of Transport proposals are to be taken as dogmatically as it is suggested was intended, or rather as a basis for further investigation; whether the experiments now being carried out in India and in Switzerland will indicate the need for revision of current practice, it is at least obvious that in this country the subject will assume a more pressing and practical importance than heretofore in view of the approaching grouping of the railways, and, as pointed out by Mr. Gribble, the consequent need of adopting a consistent system of bridge design on the grounds of economy. This is one of the problems which should engage the early and seroius attention of the chief engineers of railways shortly to be grouped together. The need for further research is evident, and this will be most effective if carried out under conditions closely approaching those of everyday practice. We do not know whether there could be useful co-operation in this matter between the engineering departments of the railways and the Engineering Research Board established in connection with the Department of Scientific and Industrial Research, but we suggest, in view of the difficulties which prevented adequate discussion of this important question at Hull, that it might with advantage be made the subject of a full-dress debate by one of our engineering societies in London, perhaps before the Institution of Civil Engineers, early in the approaching session.

Relations Between British Railways and Their Employes

Editorial in The Engineer, London.

The brightest feature of the British railway situation is found in the happy relations between the companies and their men. Never, during the hundred years of railways, has this aspect of the railway position been so good. There is, at present, a noticeable esprit de corps among the men, a greater desire to give a day's work for a day's pay, both in the operating and the manufacturing and repairing branches, that is beneficial to men and masters, and consequently therefore to the railway proprietors and railway users. We will not allow ourselves to think that a fear of the effects on labor of railway grouping is the cause of this change; though it must be recognized that one consequence of the big amalgamations now being made may be considerable reductions in the number of men employed. We prefer to believe, and will almost go as far as to affirm, that the attitude of the men is the result of the unions having been recognized and of the men themselves having been given a greater interest in the operation of the railways. This interest is not as great as Sir Eric Geddes intended when, in the outline of his proposals, made public towards the end of June, 1920, he laid down that the boards of management should include representatives of the employes, elected from and by the workers. Subsequent discussions, directly between the companies and the men's unions, led to clauses being agreed upon for inclusion in the Railways Bill—now the Railways Act, 1921—for the recognition of the three railway unions, the continuance of the Central and National Wages Boards, and for the establishment of Whitley Councils. The Whitley Councils cover local departmental committees at stations and depots, sectional councils on each railway representing the various grades, and a railway council for each railway. Above the railway councils is the Central Wages Board, and the final court is the National Wages Board. Both the companies and the men have expressed their determination to give the conferences a fair trial and, judging by what has happened since the councils were inaugurated in April, they would seem to be doing all the good that was expected of them.

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It is to be hoped that, under grouping, every effort will be made to retain the present close relationship between the companies and their men, but difficulties will have to be faced, when, for example, one system embraces the whole of the railways between London and Bristol on the south and Wick on the north, and another those between King's Cross and Elgin. It is practically impossible for one man to be in close touch with all the different districts in such a length of line, and to be well acquainted with the peculiarities of the various labor fields. There are many varieties in Scotland alone, and the Scottish character differs from that of the men in Lancashire and Yorkshire, which, again, differs from that to be found in English agricultural areas, the Potteries and the Black Country. No hard-and-fast treatment can be applied to all these classes, but with one vast system such may be attempted, and, if it is, the present happy relations will soon be broken. The Central and National Wages Boards have done, and will, we expect, continue to do, good work, but the importance of local relations must not be minimized. There are, for instance, proposals now under consideration for abolishing the guaranteed day's pay if called out, for reducing the higher rate of pay for night duty between 10 p. m. and 4 a. m., and for extending the day's mileage for enginemen from 120 to 150, and such modifications in the eight hours' day as shall ensure that eight hours' pay mean eight hours' work. The men's representatives that are dealing with these questions are in close contact with their unions, and grouping will not affect that relation. But when the twenty or thirty active companies are reduced to four, their delegates may be less responsive to the local needs. We trust, therefore, that in the details of each grouping scheme provision will be made for the retention of some of the local officers who know the men and the labor market, so that there shall, as regards railway service, be continuity of a policy which is bearing such good results.

The pH Value of Activated Sludge

Editorial in Municipal Engineering and The Sanitary Record, London.

The term pH which frequently appears in modern chemico-technical literature, particularly that emanating from America, is succinctly explained by Messrs. Wilson, Copeland and Heisig as follows:—It has been generally recognized for some years that the active constituents of all acids is hydrogen ion and that the activities of acid solutions can be represented quantitatively only in terms of the hydrogen ion concentration. Likewise the active constituent of all alkalies is hydroxide ion. Since hydrogen ion and hydroxide ion unite to form water, there is a definite reciprocal relationship existing between the concentrations of these two ions in all aqueous solutions such that the value of one determines the other. In fact, the product of these two concentrations is constant whatever the acidity or alkalinity of the solution. For this reason it is possible to record hydroxide ion concentration in terms of hydrogen ion concentration, making one scale do for both acid and alkaline solutions. For the purpose of record it has been found advisable to use the logarithms of these values, reducing the range to 16 units. The term pH is now commonly applied to the logarithm of the hydrogen ion concentration with change of sign. A pH value of 1 means 0.1 mole per litre; a pH value of 2 means 0.01 mole; a pH value of 3 means .001 mole, &c. (1 mole of hydrogen ion is 1 gramme; 1 mole of hydroxide ion is 17 grammes). A pH value of 7 indicates a neutral solution; one less than 7 an acid one; and one greater than 7 an alkaline one. The pH value of activated sludge was found to vary from about 7.7 to 8.3, with an average of 8; while 2.8 to 3.6 were the limits of its average isoelectric point, that is the point where the electric charge on the colloidal matter becomes zero and it coagulates and settles out. In experiments on the filtration of activated sludge the addition of an alkali, such as lime or lye, lengthened the time required for removing the moisture by filtration, but the addition of sulphuric acid increased the rate of filtration until a pH value of 3.2 was reached, after which further addition of acid had a marked retarding effect. Although the average isoelectric point was practically the same for all types of sludge, the actual time required for filtering a fixed quantity was very variable even when the samples had the same pH value and the same percentage of solid matter. This difference was traced to two causes. One the temperature of the raw sewage at the time of aeration, the result being much better when the temperature was above 60° F. than when below 40° F.; and the other, the extent to which decomposition had taken place after the aeration process.

Sir Alexander Houston on Water Supply

Editorial in Municipal Engineering, London.

The sixteenth annual report of Sir Alexander Houston, Director of Water Examination, Metropolitan Water Board, London, for the year ending March 31st, 1922, which has just been issued, is in no way behind its predecessors in the value of the information given to the public. In fact, each report sets a higher standard of value, because it not only notes the experiments in hand and the progress being made, but also information is given confirming or qualifying the suggestions put forward tentatively in previous reports. As Sir Alexander points out, the year 1921 was a momentous one in the history of many water undertakings, and arising out of the experience gained during that exceptional drought "conclusions of far-reaching importance may safely be reached and certain questions asked, answers to which are urgently needed." He suggests that without infringing the laws of decency and good health much less water for purely domestic purposes is apparently needed than was previously thought essential, and he expresses the belief that "even" the Ministry of Health would be satisfied in most cases under present conditions with a domestic consumption of 16 gal. per head per day. Under scientific guidance and control impure sources of supply may be rendered safe for domestic consumption, but expedients justifiable now may require reconsideration when the country becomes prosperous again. The question of rural water supplies is a complex one, but Sir Alexander thinks the future is likely to see a much greater utilization of rain water for domestic purposes in rural areas. Favorable results have been obtained in the experiments with rapid filtration, in which a comparison was made between treating the water on a slow sand filter at the usual rate of 1⅛ gal. per square foot per hour and by rapid filtration at the rate of 200 gal. per square foot per hour, followed by secondary semi-rapid filtration at the rate of 10 gal. per square foot per hour. The saving effected by the latter arrangement would be so material as far more than to pay for any additional methods of purification (e. g., chlorination) which the dictates of prudence might perhaps reasonably suggest. It is known that unfiltered water is liable to encourage the development in the distribution system of a variety of growths, not dangerous from the point of view of disease, but most undesirable in relation to question of taste, sentiment and the carrying capacity of the pipes. Most of the minute forms of life on which growths like polyzoa, sponges and mussels feed are much larger than bacteria, and it is reassuring to note that 84 per cent of the microbes were removed in passing through the rapid filters. It seems very probable, therefore, that there will be a very considerable extension in the future of rapid filtration for the treatment of London water.

A Novel Source of Power

Editorial in Water and Water Engineering, London.

A number of Italian engineers, it is stated, have devised a system of power supply which has at least the merit of originality. The idea is to utilize the difference between the surface temperature and the bottom temperature of lakes. A turbine is to be driven by the vapor of substances evaporable at a low temperature, such as ammonia or sulphurous anhydride, which will circulate between a generator heated by relatively warm water and a condenser cooled by cold water. The turbine will be placed on the margin of a lake, and the warm water will be drawn from the surface and the cold from the bottom. The difference of temperature is estimated at from 10° to 20°, so that the thermal yield would be very low; but as against this the cost of the power produced would be practically nil apart from the initial expenses. It is calculated that from the lakes of Bracciano and Bolsena, which during the summer months have a surface temperature of from 25° to 26° and a bottom temperature of from 7° to 8°, 260,000,000 kilowatts might be obtained from this system from May to September at a cost of about six centesimi (2/7 ct.) per kilowatt. We await developments of this scheme.

Slacking by Municipal Laborers

Editorial in The Surveyor, London.

Reports of the quality and quantity of the work by unemployed men in connection with roadmaking and other schemes have been so satisfactory of late that one is inclined to the belief that the earlier suggestions in another sense were not wholly to be trusted, or that there might possibly have been some mishandling of the men by foremen, whose military pugnacity was probably still existent, while it was certainly out of place translated from the field of war to peaceful civil operations. It may not seem extraordinary, things heing as they are; but at all events it is noteworthy that while casual or temporary labor is, so to speak, giving a good account of itself, complaints continue to be heard with respect to the output by members of permanent labor staffs. Slacking has become in many quarters as much a business as work itself, so much so that labor leaders have been constrained, at considerable risk to their popularity and even their position, to offer occasional doses of meticulous warning to the men against an obstinate indulgence in a habit which, whatever its purpose may be, is the tragic parent of moral decay and economic disaster. In the case of the municipal worker it might also mean inattention to sanitation, with the result of jeopardizing public health. This was the suggestion made at a meeting recently of the Crompton, Lancs, Urban District Council, when the nuisance inspector reported that he was not satisfied with the work of carting away the ashes and refuse from the houses in the township. The carts, he said, did not get the refuse away quickly enough, and consequently nuisances were caused in many places. Observation prompted the remark by the chairman that there was plenty of room for improvement in the matter. The carts, it appears, can do four loads per day comfortably, and they used to do four. Now they do only three, and the work is not done to the satisfaction of the inspector, even special instructions by the horsekeeper that four loads had to be carried being disregarded. It is obvious that such slacking and indiscipline, openly indulged in, should be no more tolerated by a municipal authority than a private firm, and in the interests of the men themselves it is to be hoped that the assertion of its authority by the council will in due course have the desired effect.

Heavy Traffic and Mains

Editorial in The Surveyor, London.

The damage done by heavy traffic, particularly in urban areas, extends not only to road surfaces and foundations, but in many cases also to the various pipes and mains which lie beneath. In this connection the Public Control Committee of the London County Council has had under consideration a complaint that these vehicles often cause damage to water mains, coupled with a suggestion that serious consequences might ensue in the event of a fire occurring simultaneously with and in the same district as the bursting of a water main. Having ascertained that the policy of the Metropolitan Water Board is to lay all new mains with at least 3 ft. of cover, and to lower existing mains to this minimum depth as and when opportunity occurs, the council decided to take no action in the matter at present. Just as this decision was being taken, the reality of an even more serious danger from the same cause was emphasized by the arrival of tragic news from Stafford, where an escape of gas from a main fractured by heavy traffic caused the deaths of two persons, while others had more or less narrow escapes. This terrible happening was caused by the penetration of gas from the street into the adjoining houses, while the occupants were asleep. It certainly appears that the general question of the possibility of damage to mains by heavy traffic demands immediate investigation, so that the public may be safeguarded against any repetition of such a tragedy. It may well be that in certain streets some more drastic preventive than that which is deemed sufficient for London's water mains should be adopted.

Influence of Rivet Holes on Steel Structures

Abstract of a Paper Presented Sept. 7 by J. S. Wilson and Prof. B. P. Haigh Before Engineering Section of the British Association

From The Railway Engineer, London.

In the opinion of the authors, current bridge designing practice has been influenced to an undue degree by conclusions drawn, directly or indirectly, from the results of "static" tests in which typical members have been tested to destruction under steady loads. Although experience has shown that the breakages that occur in practice are due to cracks produced by moderate stresses varying with the loads on the structure, experiments have not hitherto been available to show the action of such stresses on structural details. It appears to the authors that designers lacking the support of data from experimental sources have neglected lessons that might have been drawn from practical experience and have yielded to a tendency to exaggerate the dangers of "live loads."

In practical design, allowances are made for the reduction of strength due to rivet holes, and these allowances, owing to lack of information on which to base generally accepted rules, are frequently excessive. In view of this, the authors carried out the series of experiments described in the paper.

Description of Experiments. — The experiments were carried out in a Haigh alternating stress-testing machine on model plates 1½ in. wide and 1 1/16 in. thickness, 6 in. in length, with and without perforations. These dimensions were adopted to suit the testing facilities available, and to reproduce the proportions found in a typical full-size plate in a bridge member, 9 in. by ⅜ in., with 15/16 in. holes to suit ⅞ in. rivets. To simplify the preparation of the test pieces the holes were not plugged, but in later experiments the authors hope to investigate the influence of the rivets.

The machine was adjusted to apply pulsating tensile stresses and was operated in all the stresses at a frequency of 2,000 stress cycles per minute.

Figs. 1 and 2 show the method of securing the test-pieces in the machine. The test-plates were drilled at the ends and clamped between accurately fitted sheet brass packings in the steel jaws. These had screwed shanks to suit the testing machine. The test-pieces were pulled vertically, the upper end being held stationary in the fixed but adjustable head of the testing machine while the lower end was pulled and released with variable tension. The machine is fitted with an automatic cut-out that switches off the operating current as soon as the elongation of the test-piece exceeds a predetermined value; so that the test would be stopped as soon as a crack opened and before fracture caused complete severance. Considerable care was taken to achieve axial loading. The end holes were put accurately on the center lines of the test-pieces and the grip bolts were screwed up when each test-piece was in place in the machine and supporting the initial load.

Fig. 3 represents the cycle of stress, a sine-wave; and the conventional symbols used to define the magnitude of the stresses. The tension varied from a maximum (S + A) to a minimum (S — A); and in the tests in question the latter did not reverse into compression.

The mean tension value S is termed the "steady component stress"; and the semi-range of tension A, the "alternating component stress." The two components S and A can be adjusted independently in the testing machine, and in the usual method of testing are maintained at predetermined values throughout the duration of a test. When the test-piece eventually breaks, after the application of a great number of cycles, the machine automatically records the "endurance" N, usually measured in millions of cycles.

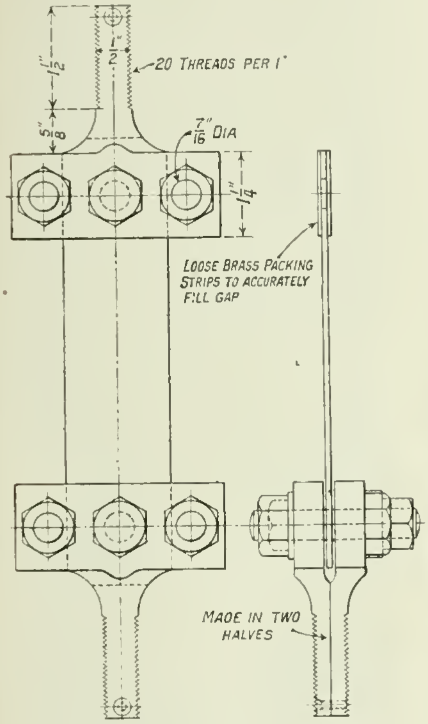


Fig. 1—Method of Securing Test Piece.

The steel used in the fatigue experiments was of a very mild quality and gave tests (under steady loads) as follows:

Sample Number.	I.1	II.1
Yield point, tons per sq. in..	13.0	12.75
Ultimate strength, tons per sq. in.	22.65	22.0
Elongation on 3-in. to ¾-in. wide, per cent	22.4	22.7

The sample numbers I and II refer to the separate plates from which test-pieces were cut. The two are nearly alike in quality, and the yield-point is 57 per cent to 58 per cent of the ultimate tensile strength.

The various experiments carried out are then described and illustrated in detail in the original paper. The authors consider that many more tests must be made before any rule could be deduced for calculating the useful net sectional area of perforated plates, and they intend to carry these out.

It will be necessary to investigate fatigue in perforated plates of steel with different values of the yield-ultimate ratio, and to contrast the behavior of drilled and punched holes. The holes in all tests so far have been carefully drilled, but when punched holes are tested a greater reduction in strength is expected. The influence of the rivets filling the holes must also be considerable, for practical experience shows that when, in the process of manufacture, the rivets are put into long members, a slight increase in the length of some or all of the parts often results.

In the meantime the authors are able to draw certain conclusions from the tests already carried out.

Conclusions.—Taking the fatigue tests, described in the paper as A, C and D, together for comparison; test-piece A, without perforation or sharp fillets, remained unbroken after being stressed from ½ ton to 12½ tons per square inch 2.85 million times, and yielded in a ductile manner when the maximum stress was raised to 13½ tons per square inch. Test-piece C, subject to the moderate concentrations of stress caused by the fillets at the shoulders, broke after 0.52 million pulsations of stress of ½ ton to 12½ tons per square inch. Test-piece D, however, with the small hole in it giving—according to mathematical considerations—a high concentration of stress, withstood 2.76 million pulsations from ½ ton to 11½ tons per square inch, after previously having endured 8.66 millions of somewhat lower stresses. Thus it appears that D was only slightly weaker than A in spite of the high concentration due to the small hole, and that C, subject to the slight concentration, was as weak if not weaker than D.

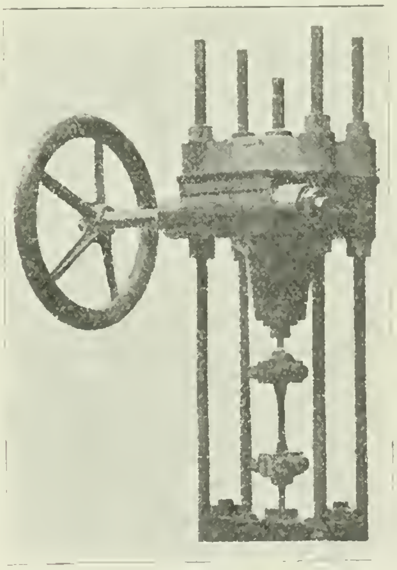


Fig. 2—View of Testing Machine.

It is remarkable that the maximum stress (S + A) in all the test-pieces that failed by fatigue, approached the yield-point for the residual metal of the net section. In these circumstances it seems impossible to avoid the conclusions that the metal adjacent to the perforations must have been strained beyond the yield-point, and that the subsequent behavior of the steel was influenced by the property demonstrated by Professors Robertson and Cooke, that mild steel immediately after yielding continues to extend under stresses much lower than the yield point. Thus the intensity of stress near the opening or edge may be 25 per cent less than the yield stress. The unidirectional stress may be changed locally to a stress that reverses from pull to push of more or less equal intensities. In such a case it might be permissible to base comparisons of fatigue strength on the alternating component stress A, and to ignore the steady stress S.

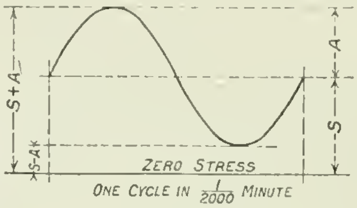


Fig. 3—Cycle of Stress.

In Table I a series of comparisons is made between the relative strengths of the test-pieces perforated with holes at the various pitches. To facilitate the comparison, the applied stresses S, A and (S + A) are reckoned on the gross sectional areas without making allowances for the holes. The endurance in all cases given in the table ranged from ½ million to 1 million cycles, and the applied loads can have been only slightly above the respective fatigue limits. For the purpose of this comparison it will be assumed that the loads were actually on the fatigue limits.

Although the comparison is based on so few tests, it indicates that test I.4 with ⅛ in longitudinal pitch, has a fatigue strength higher than I.3 and II.3, and lower than I.5 and I.6. The close agreement between the figures in line (9) and (10) shows that the stresses on the net sectional areas are practically on the yield point. The figures in lines (12) (13) and (14) give comparison based on the alternating component stress A, and on the arbitrary factor 0.45 assumed as the ratio A_0/U for the steel used.

Although the numerous recent researches, both mathematical and experimental, in stress distribution have revealed stresses so high as to alarm some practical engineers and to provoke the blunt disbelief of others, many engineers have held that the metals used in practice have a ductility and other qualities which render them able to eliminate or accommodate those high stresses.

The experiments described in this paper not only confirm that view, but also prove that under some circumstances those high stresses, even when accompanied by permanent strains, do not appreciably reduce the strength of the metal under fatigue conditions.

TABLE 1.

(1) Experiment	E	E	G	E	F
(2) Test-piece No.	I.3	II.3	I.4	I.5	I.6
(3) Holes in rows	5	5	2&3	2&3	2&3
(4) Pitch between rows	....	....	¼ in.	¼ in.	¾ in.
(5) Endurance millions	.908	1.224	0.538	0.534	0.456
(6) S tons per square inch	4.01	3.24	4.18	4.89	5.13
(7) A tons per square inch	2.76	2.78	2.87	3.50	3.67
(8) (S + A) tons per square inch	6.77	6.02	7.05	8.39	8.80
(9) (S + A)/yield	0.52	0.47	0.54	0.65	0.68
(10) (Net section)/(Gross section)	0.48	0.47	(?)	0.69	0.69
(11) Holes deducted	5	5	(?)	3	3
(12) A/U	0.122	0.126	0.127	0.155	0.165
(13) (A/U) ÷ (0.45)	0.271	0.280	0.282	0.344	0.360
(14) Net/Gross section (A/U) ÷ (0.45)	1.77	1.68	(?)	2.0	1.92

Machine Washing of Filtering Media

Equipment and Methods Used at an English Sewage Disposal Works

BY W. G. SMITH.

Manager of Heston and Isleworth Sewage Disposal Works.

From Municipal Engineering, London.

Previous to the installation of contact beds at the Heston and Isleworth Sewage Works, the treatment of sewage consisted of chemical precipitation and land filtration. The rapid growth of the district made it difficult, however, to maintain a satisfactory effluent owing to the quantity of sewage that had to be applied to the land available for filtration. It became necessary, therefore, to make some provision to reduce this volume so applied, and after due consideration the council decided to alter the system to one of septic tanks and single contact beds, still making use of the land when necessary.

This alteration was carried out in 1903-4. The three precipitation tanks, each 300 ft. long and 35 ft. wide, with depths of 7 ft. and 3 ft. 6 in. at inlet and outlet, respectively, were altered and covered with a concrete roof, and two new tanks equal in capacity to the three existing were constructed and similarly roofed over.

The contact beds are 14 in number, 160 ft. long and 60 ft. wide, with a depth of 3 ft. of material. As the treatment consisted of a single contact only, it was considered advisable not to have the material too coarse and ungraded destructor clinker ranging from ½ in. to 2 in. mesh was used.

The tank effluent discharging on the surface of the beds caused some complaints to be made owing to aerial nuisance, and in order to minimize this, the tank effluent was conducted to the main channel at the bottom of the beds, which were thus filled upwards. This method proved a great advantage as far as the nuisance was concerned, and it is still in operation, the liquid not being exposed to the air from the time it reaches the works until it leaves the beds.

It soon became evident that the beds could not be worked indefinitely without some loss of capacity, which gradually increased until a year ago, when it was estimated that since 1904 50 per cent of the capacity had been lost due to accumulation of sludge and disintegration of material.

At this time, owing to the amount of unemployment in the district, a relief work scheme was set up, and in connection with this the council decided to put into operation the work of restoring the capacity of the beds by washing the material and at the same time adding 1 ft. to the depth of the beds, making them 4 ft. in all.

Method of Hand Washing.—Hand washing was first resorted to, and the following method was adopted: Wooden platforms, fitted with iron grids 6 ft. 6 in. by 3 ft., were made and erected in the beds and moved as the work proceeded.

The grids were constructed of 1 in. by ¼-in. bars placed edgeways ⅜ in. apart. Tank effluent was used for washing, and was pumped by a 3-in. by 2-in. by 3-in. Worthington pump driven by compressed air. The dirty water and fine material, on passing through the grids, were run off into sludge lagoons, while the sludge, etc., too heavy to run was loaded in trucks and dumped.

As hand washing was found to be a somewhat slow process and a speeding up was desirable, it was considered that this could best be effected by the installation of a washing machine. Shortly before this, Mr. T. Hughes of the Hampton Sewage Works, had designed a machine for washing clinker, granite and similar materials, and a machine of this type was purchased, the makers (Messrs. A. Cross & Sons, engineers, Twickenham) undertaking to guarantee an output of 9 cu. yd. per hour of washed clinker.

Washing Machine.—This machine —which Mr. Hughes, the patentee, describes as the Heston machine— has done very good work, and on an official test washed 12½ cu. yd. per hour. For the last five months an average of 48 cu. yd. per day of 8½ hours has been maintained; this time includes fixing of engine and machine, laying of rails and preparing bed.

The machine consists of a parallel circular drum which is perforated for part of its length for the purpose of allowing the dirty water and fine material to pass out, the perforations being made according to the size of the material to be eliminated. This drum rotates on and is frictionally driven by rollers on shafts running through the framework which supports the machine and also forms a water tank.

Inside the drum, and parallel with it, plates are secured so as to form a number of divisions or shelves; these plates are strengthened by cross plates in the form of gussets, which also subdivide the length into a number of sections, these being fixed on the side in which direction the drum revolves.

Inside the drum and secured to the framework at each end, plates are arranged to form an angular trough, cross plates being fixed between the sides so that a number of angular openings are formed which correspond to the number of sections into which the length of the drum is divided. The first section of the trough forms the inlet through which the material is fed into the machine, and the last section forms the outlet through which the material, after being washed, passes out and into trucks to be taken away.

The drum revolves in water to a depth of from 3 in. to 6 in., which is maintained by a pipe running along the trough, having holes through which the water impinges on the cross plates. No overflow is fitted to the tank, but a 4-in. sluice valve is fixed at the extreme bottom. This valve is opened mechanically, and is controlled by an automatic device worked by the level of the water in the tank.

How the Machine Operates.—The machine operates as follows: While the drum is revolving, the material is fed into the machine through the first section of the trough already referred to. It falls into the water inside the drum, and is immediately carried round by the next plate to such an inclination that it falls on the cross plates forming the second opening in the trough; from this it falls into the water, is carried round by the next plate and dropped into the water again through the third opening in the trough, and so on until it reaches the end of the drum, when it is delivered, thoroughly washed, through the last opening into trucks for removal. Thus the material drops into water, is picked up and again drops into water as many times as there are sections in the drum.

The sludge and fine material, after passing through the perforations in the drum, drop to the bottom of the tank, and when the water has reached a certain level the sluice valve suddenly opens and the sludge is flushed out under a head of 3 ft. The valve remains open until the water level has dropped a certain distance (in practice about 3 in.), when the valve is again suddenly closed. By this means the necessity of frequently stopping the machine to clear sludge, etc., settling in the bottom of the tank is obviated.

The power unit was a 10 H.P. 2-cylinder petrol engine which had originally been used for driving a 4-in. centrifugal pump. This may appear rather a large engine for the purpose, a 2 H.P. power being sufficient to drive the machine, but the engine was already on the works, and it was decided to make use of it rather than purchase a special engine for the job. The washing water was pumped by a 1½-in. centrifugal pump, mounted on the framework and driven by the countershaft of the engine, which delivered effluent from the contact bed to the machine at the rate of 30 gal. per minute.

Machine washing being a new departure at these works, it was a matter for experiment as to the best position for the placing of the engine and the machine. With the first bed to be washed the engine and machine were placed outside the bed, but although this arrangement gave very good results, it was thought that the length of track necessary could be considerably reduced by moving the engine and machine into a corner of the bed itself. This was done on all subsequent beds, and proved highly satisfactory, reducing the time taken by the first system by two days.

Costs and Results.—The average cost of machine washing the five beds completed to date is £183 9s. 9½d., or 3s. 9d. (90 ct.) per cubic yard of material washed. The first 1,000 cu. yd. washed cost 3s. 11¾d. per cubic yard, while the last bed for which figures are available cost 3s. 5½d. Against this, the cost of washing by hand 4,000 cu. yd. in the manner previously described averaged 5s. 3½d. ($1.27) per cubic yard.

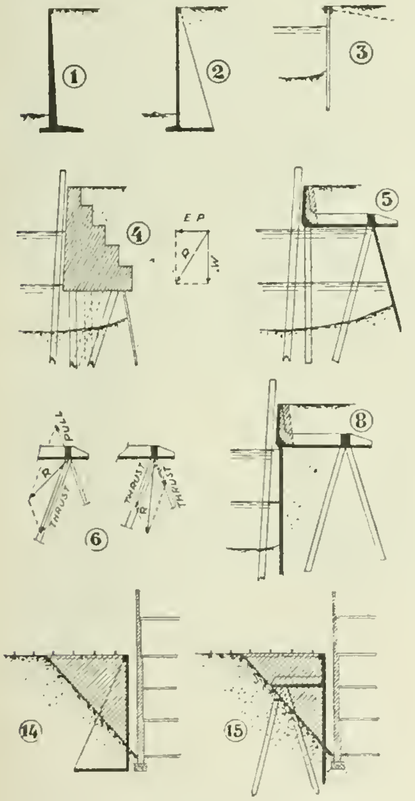
Generally, the results obtained by the above-mentioned work have demonstrated (in the case of the Heston and Isleworth Sewage Works) the following conclusions: That machine washing is (a) less costly than hand washing; (b) gives a better washed material than that obtained by hand washing; (c) is much more expeditious in working, with the important result that beds are available for use in a shorter time than when washed by hand.

Special Types of Reinforced Concrete Retaining Walls

By R. N. STROYER,

From Concrete and Constructional Engineering, London.

The use of reinforced concrete for retaining walls has resulted in certain standard types being evolved from the gravity wall, and utilizing the properties of reinforced concrete as a homogeneous material capable of withstanding both compression and tension. The usual angle design and the ribbed construction are examples of this [see (1) and (2)], these forms being so well known as to require no further description.



Types of Retaining Walls.

Where circumstances prevent or make difficult the adoption of this form of construction, such as would be the case with sea retaining walls, quay walls, dams, embankments, etc., having their substructure under water, a special type of retaining wall has been employed successfully to a large extent on the Continent, obviating the difficult and costly work behind cofferdams.

The simplest type of sea retaining wall is that sketched in (3), being a row of sheet piles, or king piles with shutters, anchored back in a suitable manner. This construction was generally executed in timber before the introduction of reinforced concrete, but can be made equally well in the latter material.

Where a more elaborate wall is required, for instance in the case of a quay wall, a fairly common type of construction is the mass concrete or masonry wall on timber piles, as shown diagrammatically in (4). The retaining sheet piles are generally at the back of the wall, the horizontal thrust from the filling behind being taken by the inclined piles. The number of these should be so determined that the oblique resultant force from the earth pressure and the weight of the superstructure are safely taken by axial stresses in the piles and without imparting bending stresses. To make the timber substructure impervious to the action of the tide it must not extend above low-water level, thus necessitating tide work of cofferdams for the construction of the wall and the timber work on top of the piles.

Quay Wall Evolved from Gravity Wall.—In (5) is shown the reinforced concrete quay wall evolved from the gravity wall just described. A line of reinforced concrete piles is taking the weight of the front wall and part of the weight of the horizontal slab with the filling over. The remainder of the weight is taken by the back line of inclined piles and the sheet piles. The functions of the horizontally-extended slab are threefold: (1) to impart sufficient weight to the inclined piles to enable them to take the earth pressure from the filling, (2) to transmit the earth pressure from the front wall to the yokes formed by the inclined piles and the sheet piles, and (3) to act as a distributing and strengthening member for resisting blows, shocks, or vibration from vessels moored to the quay.

It will be seen from (6) that by varying the depth of the slab, i. e. the weight on the back piles, the resultant acting on the pile yoke can be altered, so as to give tension or compression (or no stress at all) in the sheet piles, the inclined pile being always stressed to compression. For reasons of economy the horizontal slab, and consequently the weight on the piles, is generally kept as small as possible, resulting in a slight pull on the sheet piles; as these, however, form an excellent tension member on account of the great frictional surface, the resistance against pulling out is very considerable. The sheet piles are joined at the top by means of a strong longitudinal beam running the whole length of the wall, the inclined piles being carried well up into the beam; the front wall can either be a reinforced concrete wall, reinforced as the ordinary angle type, or a mass concrete wall may be formed as suggested by the dotted line. As the concrete piles do not suffer harm from changes in the water level, the slab can be laid entirely above high-water level, thus obviating tide work or pumping.

Closed Front Wall.—Where a closed front wall is desired the slightly modified construction shown in (8) may be employed. The sheet piles are here placed in front and form a continuous wall from top to bottom. With modern appliances for pile driving it is an easy matter to drive the piles in exact alignment, and an absolute bond between the separate piles can be obtained in several ways. A great advantage offered by this construction lies in the fact that the earth pressure is greatly reduced owing to the presence of the slab. The bending moment acting on the sheet piles is reduced correspondingly, and the necessary anchorage, being a direct function of the earth pressure, is also reduced. Otherwise the action of the slab is the same as in the previous construction, the weight on the pile yokes being so arranged that the back piles have little or no tension. It might be held that the back row of inclined piles could be omitted, since the structure could be so designed that the former had neither tension nor compression. In actual practice the back piles are, however, always driven as an additional safeguard against slight variation in the earth pressure, which it may have been impossible to foresee in the initial calculation. It will be noticed that a surcharge behind the front wall tends to increase, rather than otherwise, the stability of the structure owing to the extra weight over the slab, and in this respect this type of wall differs from most others.

The advantages of the quay wall just described are shortly:

Stability against earth pressure under all conditions of varying load and water level, the factor of safety may be made as high as desired.

Resistance to outside forces, shocks, vibration, etc., owing to the great moment of inertia of the angle section.

Immunity against scouring at the root of the foundation.

Homogeneousness of substructure and superstructure.

During the past decade a number of quay walls of this type have been built, in Germany by Messrs. Christiani & Nielsen, Hamburg, and in this country, to the design of the writer, by Messrs. Somerville.

An adaptation of this construction for land purposes is shown in (14) and (15), in the shape of a railway retaining wall necessitated by the widening of the line. The work, which had to be executed without interfering with the existing traffic, was greatly facilitated by substituting the pile yoke design for the ordinary angle or gravity wall, which would have necessitated a large amount of dangerous excavation work. The design adopted left the embankment untouched, all the piles being driven into the bank from a temporary staging, and after filling up to the level of the slab, the latter and the top wall were built and filled up. The length of the wall was some 600 ft., and the average height 25 ft.

London Water Supply.—The average daily quantity of water supplied directly to consumers in the metropolis during the year 1921 from various sources was: 154,254,500 gal. from the Thames (60.98 per cent of the total quantity supplied); 45,425,800 gal. from the Lea (17.95 per cent); 53,099,600 gal. from springs and wells (20.99 per cent); 94,500 gal. from the Hanworth gravel beds (0.04 per cent); 95,200 gal. from the ponds at Hampstead and Highgate (0.04 per cent). In addition, a further 1,931,400 gal. were supplied in bulk to adjacent water undertakings, of which 1,719,200 gal. were from the Thames and the remainder from wells.—Water and Water Engineering, London.

Municipal Outdoor Swimming Pools

Design and Construction Features of More Common Type and Description of German Floating Bath

By CHARLES ELLIOTT,

From Concrete and Constructional Engineering, London.

In view of the growing popularity of outdoor bathing it is not surprising to find park improvements in many cities have in recent years included the provision of outdoor bathing pools. Of the numerous types of pool installed, the rectangular basin of concrete construction stands out with especial prominence. Concrete construction is ideal for bathing pools. It ensures strength, watertightness, freedom from expensive maintenance, and absolute permanence. Well-made concrete being dense and impervious, a pool constructed of this material may also readily be kept in sanitary condition, thereby adding very greatly to its attraction and popularity.

Selection of Site.—In selecting a site for the outdoor bathing pool, a location should if possible be chosen where natural drainage of the soil is good. The site should also be such as to permit of the pool bearing an harmonious relation to surrounding structures or landscape details. Attractively arranged surroundings add enormously to the enjoyment of bathers, and furnish a pleasant contract to the sometimes depressing surroundings of the indoor swimming bath.

The dimensions of the outdoor bathing pool will, of course, be largely governed by local conditions. In the accompanying drawings a design is suggested for a small rectangular pool 60 ft. long and 20 ft. wide. Any change in the dimensions given would naturally involve modification of certain details of the design, such as increasing or decreasing the quantity of reinforcing utilized, and so on. The design reproduced (Fig. 1) has been extensively adopted in the United States, in which country considerable experience in bathing-pool construction has been obtained.

Design Features.—The walls of this pool are designed on the assumption that the soil has a bearing power of not less than 4,000 lb. per square foot. Should the bearing power be less than this figure the footings would require modification accordingly. In excavating for the footings the trench should be made large enough to provide sufficient excavated space, after setting up the form for the exterior of the footings, to receive the 6-in. concrete drain tile laid around the entire exterior of the footing. The lowest point of this drain is connected with another tile line leading to a convenient outlet situated low enough to permit of uninterrupted drainage. After footing forms have been set up and braced, reinforcing for the wall should be erected, being assembled by wiring at all intersections, and temporarily stayed in position by supports placed above the footings. Reinforcement should also be temporarily secured to vertical supports so that it will remain correctly assembled in proper position while concrete is being placed in the forms.

Construction Methods.—The footings should be built up to the bottom of the fillet, at which level a notch 2 in. deep and 4 in. wide should be formed in the concrete by forcing a slightly beveled piece of 2 by 4 timber into the soft concrete and allowing it to remain until the concrete is hardened. The notch or groove formed in the concrete will key the wall into the footing and increase the water-tightness of the construction joint. In addition to the notch, the concrete should be left level and roughened. Before the concrete for the wall is placed, the surface of the footing upon which the wall will rest should be scrubbed clean, drenched with water, and flushed with a mortar composed of one sack of Portland cement to 2 cu. ft. of sand. This mortar coat should not exceed ¼ in. in thickness, and before it has hardened the concrete for the wall should be placed. Whenever work is stopped, so that the concrete will have hardened before the next layer can be placed. the same precautions should be taken to ensure a watertight joint.

After the concrete in the footing forms is 24 hours' old, forms may be removed and the timber used for the wall forms, the forms being completely built after the temporary supports carrying the reinforcing at the bottom of the fillet have been removed. The upper ends of the reinforcement should then be temporarily stayed to the forms to hold the rods in correct position while concrete is being placed. Wall forms should consist of sound timber planed to a uniform thickness, either tongued and grooved or with beveled edges to make tight joints and prevent leakage of mortar. Special attention should be given to bracing forms and to wiring them together to prevent any sagging or deformation. The upper ends of the reinforcement should then be stayed to the forms to hold it in correct position while concrete is being placed. Provision should also be made to hold the reinforcement at the proper distance from the face of the form.

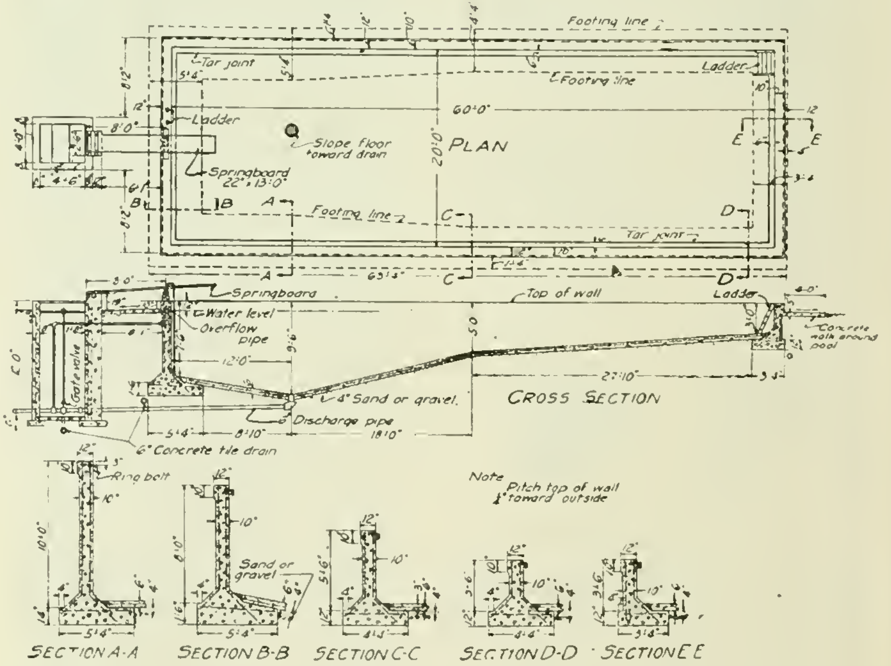


Fig. 1—Design for an Outdoor Bathing Pool.

If only bank-run gravel is available the material must be screened by separating it into at least two parts. the sand being that material which will pass through a screen having four meshes to the linear inch, the pebbles being that material which will not pass this screen and which ranges from ¼-in. particles up to those having a maximum dimension of 1 in. The concrete mixture for the entire construction should be one sack of Portland cement to 2 cu. ft. of coarse, clean, well-graded sand, and 3 cu. ft. of hard, clean well-graded pebbles of broken stone. Water used for mixing concrete should be clean and free from oil, alkali, acids, and vegetable or other organic matter; and enough water should be used to produce a concrete of jelly-like consistency.

Concrete should be placed in layers not deeper than 9 in., each layer being well puddled with a rod and the forms rapped with wooden mallets. This helps to settle the concrete properly in the forms, completely surrounding the reinforcement and working into difficult corners. It also tends to reduce air and sand pockets, and, by forcing the mortar against the forms, produces a dense, smooth, watertight surface. The forms should be well braced to prevent bulging due to pressure of the wet concrete. Under favorable weather conditions wall forms may be removed after 36 hours, but the back filling should not be done until the concrete is at least four weeks old, nor should the pool be filled with water for at least four weeks after the last concrete has been placed. Any air or pebble pockets on the interior surface of the wall after forms have been removed should be at once filled with a 1:2 cement-sand mortar.

After wall forms have been removed the soil upon which the floor is to rest should be graded to proper level and slope, a 4-in. sand cushion placed and solidly compacted by rolling and tamping, and wedge-shaped wooden strips placed around the edge of the inner fillet to form the joint between floor and walls. The concrete for the floor should then be placed, reinforcement being laid 3 in. from the top surface, as shown. The concrete should be struck off by using a wooden strikeboard and given its final finish by hand floating with a wood float. This plan contemplates continuous concreting of the floor. If it is impossible to carry on the work in this manner provision must be made for joints that will make the floor consist of two or more slabs.

For at least 10 days after wall forms have been removed the concrete should be protected from sun and wind by canvas, in addition to which the covering and the concrete itself should be wetted down several times daily. After the concreting of the floor is finished the work must be protected to prevent too rapid drying out of the concrete. Protection should be continued for at least 10 days, after which the strip at the outer edge of the floor may be removed and hot tar or asphalt poured into the space between floor and fillet to seal the joint.

Overflow and discharge pipes should be provided for as shown; the inlet pipe is not indicated, as its location depends upon local conditions. It is particularly necessary that for inexpensive operation the facilities for filling and emptying the pool be as simple as possible. The pool should be located so that gravity flow will empty it when necessary to change the water for cleaning the pool or for other reasons.

Materials Required.—The design which has been described has been made with every regard for economy of materials and equal consideration for efficiency of design. The following approximate estimate will enable one to determine the probable cost as influenced by the price of materials in the particular locality in question:

Portland cement	15 tons
Sand	50 cu. yd.
Pebbles or broken stone	74 cu. yd.
Reinforcement	1½ tons
Concrete tile	180 ft. of 6-in.
Timber	6,000 ft.

As no bathing pool is complete without a springboard, provision should be made for one at the deep end of the pool. It may be anchored to the wall of the manhole containing discharge valve, etc., as indicated, or to a separate block of concrete. The suggested design shows two ladders, one near the springboard and the other near the corner at the shallow end of the pool. By embedding short piping at the top of the wall and floor when the concrete is placed, and later fastening the ladder to these, the work of installing the ladder will be made very simple. To avoid slipping, the top surface of the pool wall should be left rough, and for the safety of swimmers a hand-hold should be provided, encircling the pool. Ring bolts should be embedded near the top of the inside wall as indicated. These should be spaced about 10 ft. apart, and through them may be run a rope or pipe.

Floating Baths.—In Germany, America and more recently Holland, swimming baths have been constructed on pontoons in such a manner that they rise and fall with the variations in the water level. The largest, which is at Kampen, is shown in the accompanying illustration. The pontoons are of reinforced concrete.

A notable feature of this structure is its great length and the use of four very large pontoons in addition to the 12 smaller pontoons of more usual dimensions. The total length of the swimming bath is over 200 ft. and its width 76 ft. Along each side and parallel to the stream are two large pontoons, and at each end are three smaller ones. Three more small pontoons, united below the water line by iron girders, divide the bath into two parts: the smaller one (57 ft. by 55 ft.) for learners and the larger one (103 ft. by 55 ft.) for more experienced swimmers. The smaller bath is still further divided into two portions by three small pontoons, a suspended cage being supplied to each portion—a shallow one for beginners and a deeper one for experienced swimmers. Galleries are provided for visitors.

The larger pontoons are united by iron lattice work, which also serves to support the galleries. The dressing cabinets and other offices are on the large pontoons. The large pontoons are each 100 ft. long, 10 ft. wide and 4 ft. deep, and were built in accordance with designs found successful for lighters and other strong craft. The ends of the pontoons which are in contact are rectangular, but the opposite ends are pointed, the sides meeting at an angle of 45°. To prevent sinking in the event of a leak or a severe blow damaging the sides, these pontoons consist of a series of seven closed chambers, with a concrete roof or deck over all. They are strengthened by a series of transverse ribs, spaced uniformly, and a longitudinal web. The smaller pontoons are similar in design. All the pontoons were built on long stocks, from 6 to 8 weeks being required for their construction and a further 3 weeks for hardening.

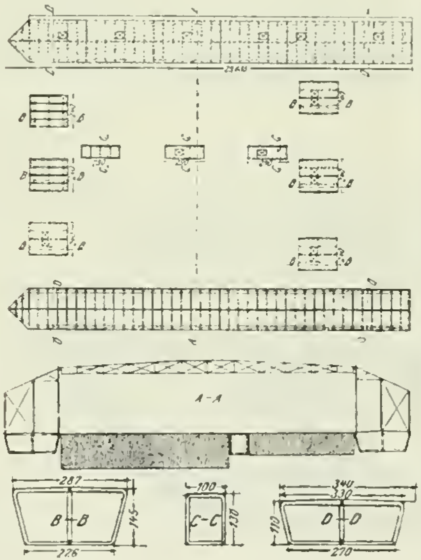


Fig. 2—Half Plan and Sections of Kampen Swimming Basins on Pontoons.

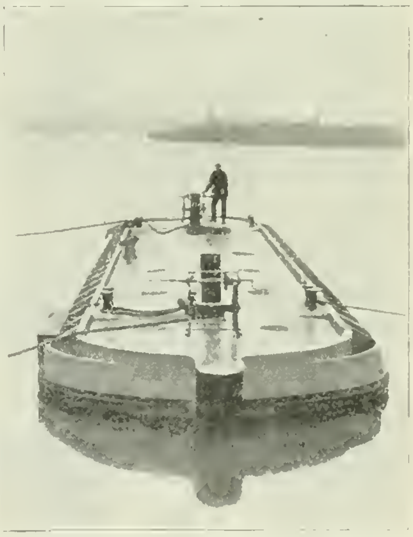
Examination for Railroad Auditor.—The U. S. Civil Service Commission announces an open competitive examination for railroad auditor. Vacancies in the technical staff of the Income Tax Unit.

Floating Reinforced Concrete Caisson as Precautionary Measure for Closing Oil Dock

From The Engineer, London.

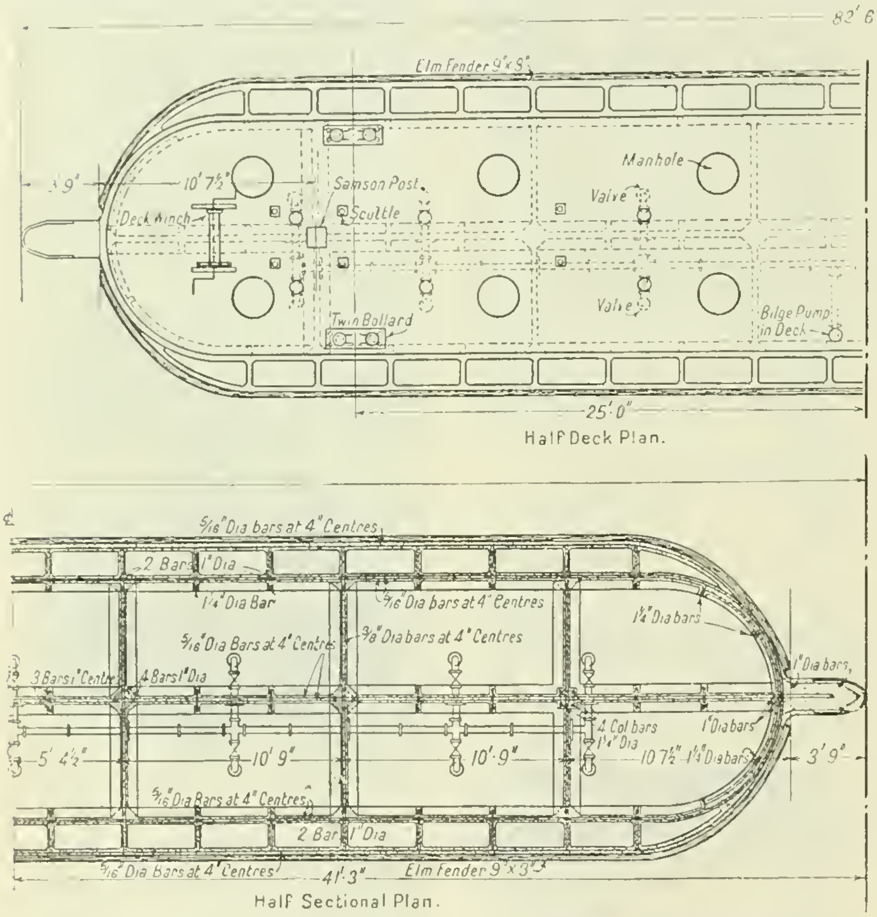
Very large quantities of petroleum and oils of a flash point not lower than 73° F. have been imported into England via the Manchester Ship Canal during the past few years. Heretofore, however, the canal company has not permitted the importation of oils and spirit having a flash point below 73° F. owing to the want of a safe place in which to moor the vessels while discharging their liquid cargoes. This difficulty has now been overcome by the provision of a separate dock and discharging equipment in an isolated situation, in which the vessel can be shut off from the canal by means of a floating reinforced concrete caisson—a precautionary measure in case of fire or of escape of the spirit.

The dock is on the estuary side of the canal, while the oil companies' premises and land for future developments are on the opposite side, with road and rail facilities adjoining. The principal dimensions of the dock are as follows: Length, 600 ft.; width, 100 ft.; depth of water, 30 ft.; and width of entrance, 80 ft. The dock is placed at a convenient angle with the canal to give easy access for the ships, and the approach is provided with two reinforced concrete dolphins on one side, a recess being provided for the caisson when this is not in use. In each of the main concrete piers at the entrance a vertical groove of a modified V shape, faced with granite, is provided, and into these recesses suitably shaped projections on each end of the caisson fit, one end being secured by a wedge which is raised and lowered by a winch on the quay.

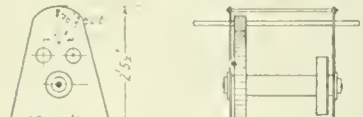


Reinforced Concrete Caisson.

As mentioned above, the function of the caisson is to act as a fire-stop at the dock entrance by preventing the escape into the canal of blazing oil in the event of a fire occurring within the dock. The caisson is a box-shaped vessel, nearly rectangular in section, with semi-circular ends terminating in substantial stem and stern posts. The length over all is 82 ft. 6 in., the beam is 12 ft., while the depth from crown of deck to keel is 10 ft. 3 in. The deck has a chamber of 4 in., and the bottom is formed with a fall of 6 in. from the bilges to the keel. A fore-and-aft central wall, together with 6 transverse bulkheads, divide the caisson into 14 separate water-tight compartments. At water level the hull is provided with timber fenders bolted to a reinforced concrete counter carried by wings springing out from the upper parts of the sides. The total weight of the caisson without ballast is about 125 tons, and its draught is about 5 ft. 6 in. As the working draught is 8 ft., a certain amount of ballast, consisting partly of mass concrete and partly water, is placed in the various water-tight chambers to give the requisite flotation. Each of the compartments is provided with an air-tight manhole frame and cover on deck for purposes of access, also a scuttle plug and sounding pipe. The deck equipment comprises two deck winches, one near each end, and four double-cast iron mooring bits, two on each side of the vessel. For the purpose of adjusting the water ballast, and also for pumping out any or all of the ballast chambers, each compartment contains a 3-in. sluice valve connected to a central suction pipe leading to a 3-in. diaphragm hand pump fixed on deck. Each valve being operated by a spindle terminating in a water-tight box, the various compartments can be dealt with singly or any number at a time as may be desired. The stem and stern posts, and also the portions of the "Samson" posts above deck level are sheathed with steel plates ⅝ in. thick. With the exception of the hull bottom, which is 4 in. in thickness, the concrete throughout the vessel, comprising the sides, deck, bulkhead and center wall, is 3 in. thick, splayed out at the various intersections. The sides and also the center fore-and-aft wall are stiffened by vertical ribs spaced about 3 ft. 6 in. apart.

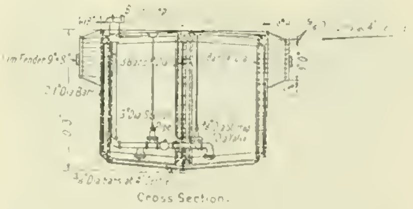


Half Deck Plan and Half Sectional Plan of Reinforced Concrete Caisson.

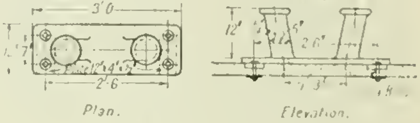


End and Front Elevations of Deck Winch.

The reinforcement throughout the whole of the caisson consists of round mild steel bars of ordinary commercial section. No fabric or steel bars of special form were employed. In the case of the walls, bulkheads and bottoms upon which the pressure might fall from within or without, according to the manner in which the chambers might be charged with water ballast, the reinforcement had to be provided near to both surfaces. The deck, however, only required reinforcing in the usual way for downward pressures. The reinforcement in the floors, walls, bulkheads and deck consists of ⅜ in. and 5/16 in. diameter main and transverse bars suitably spaced and wired together at intersections. Heavier reinforcement, consisting of 1 in. and 1¼ in. diameter bars, is introduced in the vertical stiffening ribs, Samson posts, stem and stern posts; and also in keel, bilges, gunwales and along the top of the center wall. Whenever necessary, as, for example, in the stiffening ribs, steel stirrups are inserted to take up the shearing stress.



Cross Section of Caisson.



Twin Bollard of Caisson.

The whole of the concrete throughout the caisson is composed of portland cement, sand, and ⅜ in. Dalbeattie crushed granite, mixed in the proportion of 224 lb. cement, 3¾ cu. ft. sand, to 7½ cu. ft. granite. The caisson was built by Messrs. B. Morton and Sons, Quay St., Manchester, in accordance with specifications prepared by H. A. Reed, chief engineer to the Manchester Ship Canal Co., who is responsible for the whole of the scheme.

Motor Vehicle Taxation in Great Britain

From The Engineer, London.

At the invitation of the Ministry of Transport a number of organizations representing various branches of the motor industry have submitted proposals for a new form of taxation. These bodies include the Royal Automobile Club, the Royal Scottish Automobile Club, the Society of Motor Manufacturers and Traders, and the Motor Trade Association. The proposed system is chiefly a tax on motor spirit, its main features being as follows: A flat rate duty on all motor spirit to be levied at the port of entry; all motor spirit, derived from imported crude oil to be taxed; a moderate registration tax on all motor vehicles; no rebates of motor spirit tax for any class of road motor; no tax on benzol or any other motor fuel that is wholly produced in this country; duty-free petrol for aviation and industrial purposes, which is to be supplied by a simple permit system; motor spirit to be defined by a flash point and distillation tests; the use of paraffin in internal combustion engines to be allowed by special license; steam and electric vehicles to be taxed by the existing method. It is stated that a definition of motor spirit has been drawn up which will solve the difficulties encountered in the administration of the petrol tax which was formerly in operation.

Changes in Retail Prices of Food.—The retail food index issued by the United States Department of Labor, through the Bureau of Labor Statistics, shows that there was an increase of 2 per cent in the retail cost of food to the average family in October as compared with September. For the year period Oct. 15, 1921, to Oct. 15, 1922, the percentage decrease in all articles of food combined was 6 per cent. For the 9-year period, Oct. 15, 1913, to Oct. 15, 1922, the increase in all articles of food, combined, was 37 per cent. The index numbers based on 1913 as 100, were 140 in September, and 143 in October, 1922.

Recent Experiments in Sewage Disposal

Abstract of a Paper Read at the Annual Summer Meeting of the British Association of Managers of Sewage Disposal Works

By J. W. HAIGH JOHNSON,

In the evolution of sewage treatment it will be noticed how the method of operation moves first in one direction and then back again to some phase of the original method, in much the same manner as a clock pendulum, from the closely packed, relatively unaerated water-logged sterile condition of the early sedimentation method to the air enclosed, relatively dry, open material teeming with life of the sprinkler filter. The next step in the evolution is a very obvious one—an attempt to combine the benefits of both systems without introducing the defects of either. The first system suffers from having too much water and too little air; the second from too little water and too much air and inert material. The activated sludge method is therefore the actual outcome of a combined system. The future line of evolution seems naturally to lie in the direction of increased aerial activity or efficiency, and it is conceivable that the pendulum will swing back when some genius introduces inert material again; but this time not for the purpose of supporting the organisms but for holding the air bubbles in longer contact with the agitated material. Naturally the air being supplied by mechanical means and this being one of the great items of the cost of treatment, greater use or efficiency will be exercised in its application.

Before leaving this interesting subject of evolution, there is still another swing which the pendulum is very likely to make—namely, we may return to the early form again; i. e., involving precipitation and settlement. Unfortunately, the sewage problem is the sludge problem, and even with activated sludge treatment the mud still requires the greater part of the treatment; if, therefore, we can persuade the suspended matters in the sewage to separate out in the early stages the treatment of the remaining liquid portion should be rendered much simpler. I see no reason why a short agitation with activated sludge in some form or another should not secure a separation of solid matter equivalent to that of an Emscher tank, while the supernatant liquid could be passed on for further treatment.

Occasionally it has been suggested that the activated sludge treatment does not depend upon organized life, and that similar results can be obtained by relatively inert substances in a state of fine division. Microscopic examination shows that not the slightest doubt can be entertained as to its general zoogloeal character, intermixed with debris of polluted origin, while its thermal death point and other chemical and physical attributes support this view. The high nitrogenous content is not inconsistent with this view, as I have obtained a bacterial sediment from such material which contained about 8 per cent of nitrogen. The relatively high percentage of nitrogen contained in activated sludge naturally affords a food supply capable of supporting the life of many forms of organized life; such characteristic forms as verticella, carchesium, and opercularia often develop along with numerous smaller and less conspicuous forms. Occasionally I have noticed myriads of paramoecia suddenly appear in the effluent from this treatment, and apparently they were associated with the unusual purity then obtained. Although this development of animal and vegetable forms in the same liquid may not be exactly one of symbiosis, undoubtedly their appearance materially assists purification by consuming some of the excessive bacterial elements. Recently great advances have been made in controlling certain well-known biochemical reactions; thus during the recent war sugar suddenly disappeared from the German dietary, to appear later in the form of nitro-glycerine—and this by a modification of the well-known fermentation process used for producing alcohol. The application of specialized biochemical treatment of sewage has not yet been attempted. Its possibilities, therefore, are unknown, but from analogy with the recent progress made in the older biochemical processes one can reasonably expect that great improvements are still possible even in sewage treatment.

Activated Sludge Method Intense Form of Biological Activity.—The activated sludge method is the most intense form of biological activity yet applied to the purification of sewage; owing to the very small size of the reacting particles it is perhaps more susceptible to change of condition than any other. Even the amount and strength of sewage being treated have a measurable effect on the activity of the process, since with the character or strength of the sewage often varying from hour to hour it is desirable to safeguard the process from such disturbances. The use of a large receiving tank will naturally tend to produce a more uniform flow to the activated sludge plant. On the other hand, if the activated sludge tank capacity and the flow of sewage are such that the liquid should circulate around the plant two or three times before purification is complete, then by circulating a full quantity of liquid and only drawing off a portion equal to the hourly flow, which will only equal a fraction of the total amount of liquid being circulated, a very adequate protection is afforded to the process. This dilution method has the effect of not only diluting the liquid undergoing treatment but diluting it with a considerable volume of purified liquid, and, further, the concentration of the pollution is thus very much reduced, as is also the effect of any substance having a direct deleterious effect on the process. Again, before another small dose is added the liquid must circulate round the works. In this way the organized entities of purification have additional opportunity of becoming acclimatized to inimical action.

The activated sludge method of treatment is generally applicable to the usual type of liquid capable of treatment upon a sprinkler filter installation. As already noted, the increased activity of this method is obtained by the more finely divided character of the active elements of purification and the greatly increased volume of liquid with which they come in contact.

The process works well in such liquid when neutral or slightly alkaline in character, and if it is necessary to treat a liquid of alkaline character uniformity in alkalinity is perhaps more essential for efficiency than the actual amount. If the alkalinity be very considerable the process seems at first to fail; but continued application will effect purification which in the early stages often produces remarkable amounts of nitrates, and later correspondingly large amounts of nitrates. Liquids of acid reaction are not, however, so readily purified, and unless some source of a suitable base is available nitrification apparently ceases.

Gaseous Interchange During Purification.—Until quite recently no very satisfactory attempt has been made to estimate the amount of oxygen required by a given liquid during the process of purification. Dr. Dunbar's attempts working with a contact bed are perhaps the best known, but even in this case the results were better calculated to measure the production of CO_2 during the resting stage, and certainly did not provide any reliable figures for the amount actually absorbed by the liquid during the process of purification. The results obtained give the volume of CO_2 produced in the filter atmosphere during the resting stage. Other methods which may give comparable results are Royal Commission oxygen absorbed test, or Prof. Adey's direct measure of oxygen absorption by polluted liquids performed in a special apparatus designed for this purpose. Even these figures can only give us the amount required for oxidation on biochemical lines. It is obvious no accurate results can be obtained unless the proper activated type of mud be used.

By means of the following apparatus it has been possible to measure the actual requirements of the process. It should be noted that the results given in this paper do not include the amount of oxygen required to produce nitrogen oxidation products—i. e., nic and nitrous N—as the process was stopped before this stage was reached. The amount of oxygen which a sewage having a four hours' oxygen absorbed of 10 parts per 100,000 required under these conditions is approximately equal to three-quarters of its own volume, or five times this amount of air. It is obvious that in actual operation—whether diffusers or other means of supplying the air be adopted for this purpose—a very much larger volume of air will be required for "blowing." As a result of experiments it seems fairly reasonable to assume that during the whole process not more than 1 per cent of the available oxygen in the air is absorbed during the short period of contact between the air-bubbles and the liquid. On these grounds it follows that the amount of air is about 80 times the volume (or 12 cub. ft. per gallon) of the sewage treated. Undoubtedly part of this large volume is absorbed directly from the air at the agitated surface of the liquid as it flows through the tanks, but even after making liberal allowance for this, there still remains a very large volume which must be supplied mechanically. By this means it was found that 5 to 10 times or more oxygen was required than was indicated by the four hours' oxygen absorbed figure.

It will be obvious that a liquid which oxidizes readily will absorb the oxygen more quickly than one which is not so readily oxidized; the apparatus can therefore be used to determine the effect of adding a certain type of sewage or trade effluent on an existing sewage.

After a "run" we obtain (1) the actual volume of oxygen which has been displaced from the cylinder during the process; (2) the total volume of CO_2 formed and absorbed by the caustic in the absorber; (3) any change in the atmosphere remaining in the vessel, and thus make any necessary corrections.

In this way we obtain (b) the volume of oxygen used and (a) the volume of CO_2 found in the absorber.

The ratio $\frac{a}{b}$ varies $\frac{1}{1.5}-\frac{1}{2.8}$ per litre of liquid treated. "a" represents completed carbonaceous oxidation; b — a represents internal or intromolecular oxidation, and doubtless inculdes the formation of water from carbonaceous compounds or the nitrogen oxidation products prior to nitrous and nitric acid formation.

The very large amount of oxygen which we have seen is required for the purification of sewage at once raises the question of the admission of unpurified sewage to streams. The discharge of 1 vol. of sewage (four hours' oxygen) of 10 parts per 100,000 would require the whole of the oxygen contained in 100 vols. of fully aerated water fully to oxidize it, so that a dilution of 200 times might at first sight be thought sufficient. The difficulty, however, arises from the fact that the solid matters tend to separate and settle out in the bed of the stream, so that only a small fraction of the 200 parts of dilution liquid contribute their oxygen to the mud, which requires the major portion of the oxygen. Again, when the stream is sluggish the amount of mud which collects may be so considerable that the oxygen content of the surrounding water becomes so reduced that even septic conditions may be established.

Similar remarks applied to the liquids discharged under storm conditions. If the downpour be of such intensity that the stream receiving the storm discharge is thoroughly stirred up, little or no danger may be apprehended; but it often happens that a downpour bringing storm overflows into operation fails materially to alter the condition of the stream. Under such conditions it will be seen that the discharge should generally be as well treated as possible. It is somewhat unfortunate that the devices at present used for treating storm water are not calculated to give very efficient results. The standby or storm tank, even if of sufficient capacity to hold the polluting portion of the discharge, suffers from the inherent defect that treatment is delayed while some favorable opportunity presents itself; and further pumping is often necessary to complete the treatment. The storm filter offers much better prospects, but, as we all know, the efficiency of a filter cannot be maintained unless it is kept in active operation, and for this purpose the storm filter should receive doses of liquid at fairly frequent intervals. This virtually amounts to saying that the filtering capacity of an efficient works should be considerably in excess of the normal requirements (land or constructed filters).

It is possible that the activated sludge process may be found to provide these requisite elastic properties so essential for dealing efficiently with storm waters, as in this process we have no filters to choke by the rapid treatment of excessive quantities of liquid which are receiving only indifferent preliminary treatment.

Rate and Intensity of Oxidation.—In the first place we should realize that the reactions occasioned in these bio-chemical processes are of an entirely different order from anything we are accustomed to in ordinary chemical reactions.

We have already noticed that the amount of oxygen required to oxidize biologically a sample of sewage is about 10 times that required by the usual chemical means of acid and permanganate. This serves to indicate the great intensity or thoroughness of the biological action as compared with the use of ordinary chemical reagents. In order further to illustrate this remarkable fact, I need only mention one or two other well-known instances.

I will take two examples, the oxidation or urea and the production of oxygen from carbon dioxide. The former is an oxidation which goes on quite readily in sewage purification, and the latter a well-known everyday occurrence in nature. Yet, if we attempt to perform the former by chemical means, we usually have recourse to such violent oxidizing substances as bromide. The latter would, I think, present a very difficult problem to the best-equipped chemist among us. Yet, bio-chemically, it is performed quickly and efficiently by photo synthesis in the green leaves of our vegetation. We can therefore obtain through bio-chemical means oxidation much easier than by ordinary routine chemical reactions.

Rate of Oxidation.—Any factor which increases the oxidation concentration in the liquid will therefore accelerate the process; breaking of the surface by baffles, increased time of contact between air or oxygen and the liquid, particular vitality of organisms at time of treatment, undue resting or over treatment reduce initial rate of absorption. Although an increased agitation produces an unusual rate of absorption and consequently, one would argue, a quicker and more efficient treatment, experience shows that over-agitation produces an unsatisfactory effluent as the mud is disintegrated and settlement becomes in consequence slow and unsatisfactory.

One cannot reasonably introduce the subject of activated sludge without saying something about its apparently high nitrogen content. The remarkable amount of this substance which occurs in the sludge is at once a considerable asset to the process. As I have already mentioned, this nitrogen appears to be associated with the bacterial or zoogloeal elements present in the material.

The nitrogen cycle during oxidation is perhaps the most important part of sewage purification. We know that as oxidation proceeds the complex nitrogenous bodies present in the crude liquid gradually become simplified, yielding such bodies as amides, amines, and finally ammonia. From this point the process is perhaps more readily followed; the first stage yields nitrites and eventually nitrates. Much of the original nitrogen present in the crude sewage passes away with the effluent. Future efforts will doubtless be directed to preventing or minimizing this loss. Some observers have stated that fixation of nitrogen takes place in the activated sludge process. However this may be there is undoubtedly a considerable loss on the complete cycle. Hitherto one has experienced the greatest difficulty in maintaining the composition of the air constant in these experiments for any length of time. The percentage of oxygen is always on the decrease, which one presumes is due to nitrogen increase. Unfortunately this increase is not regular, and one is inclined to suspect that evolution becomes more vigorous as the process proceeds.

The Potable and Public Service Water Supply Systems of Paris

From Engineering, London.

At the present time, the Paris water supply is on two distinct systems, completely independent one of the other. The first, which is styled the "Service Prive," supplies potable water of two different kinds, or rather, we should say, of two different origins. The water proceeds from different springs at a distance, which are drawn upon with the greatest care, and is led in completely closed-in conduits to covered reservoirs, whence it is distributed by piping to the water taps in the dwellings of the consumer; or, alternatively, of filtered river water taken from the Seine and the Marne, above Paris, which, after passing through filter beds and a sterilizing installation, is pumped up to the distributing reservoirs. The second system, the "Service Public," supplies raw water taken from the Ourcq, Seine and Marne, which is pumped into separate reservoirs, whence it is distributed by separate mains. This latter water is that used for washing down the Paris streets, for washing down yards and watering public gardens, for flushing sewers, for display purposes, and to meet the needs of works and industrial establishments, railway stations, laundries, etc.

The Supply from Springs.—The water from springs is taken either at the natural outflow, or by means of shafts or underground galleries where provision is made for inspection. There are four aqueducts for conducting the water to Paris, built partly in trenches and partly underground, and crossing the valleys either by means of cast-iron pipe siphons or on bridges. The Dhuis supply was completed in 1865. The daily supply from this source varies between 15,000 and 24,000 cub. m. (about 4,400,000 gal.). The spring from which the system delivers the water, by gravity only, is in a calcareous formation of the Tertiary system. It is located near Pargny and Conde-en-Brie, in the Aisne Department, and ran formerly in the Dhuis, a tributary of another small river, itself a tributary of the Marne. The aqueduct, which starts from the spring basin and ends in Paris at the Menilmontant reservoir, has a total developed length of 131 km. (80 miles), and a down gradient of 0.10 m. per km. (1 in 10,000). It is ovoid in section, 1.76 m. (5 ft. 9 in.) high, and 1.40 m. (4 ft. 7 in.) wide. The siphons consist of a line of cast-iron pipes, 1 m. (3 ft. 3 in.) in diameter. The Dhuis aqueduct being mainly underground, there are but few surface constructions; the most important of these are the bridge-aqueducts over the Grand Morin and the Marne. This system was twice damaged by the Germans during the war, but the catchment over a wide area was subsequently made quite healthy again and the damage repaired at the Armistice.

The Vanne Supply.—The Vanne supply was put in hand in 1867. The work was stopped by the war of 1870-71; it was resumed in 1872, and completed two years later. The supply from this source amounts to from 100,000 to 120,000 cub. metres (about 24,000,000 gal.) per day. The springs in the Vanne Valley, above Sens, proceed from a chalk formation, and are in two groups, the high springs, the water from which has an outflow at elevations of from 207 to 136 m. (680 to 445 ft.) reach Paris by gravity, and the lower springs, at levels of 93 to 88 m. (305 to 285 ft.) necessitating pumping up into the aqueduct. The pumps for this purpose are operated either by hydraulic turbines, driven by the Vanne river, or by steam engines. Another pumping plant, consisting of water turbines and steam engines, further down-stream, also delivers into the aqueduct the water of another source which was tapped in 1885 in a neighboring valley. The aqueduct is 173 km. (107 miles) in length, and is on a gradient of 0.10 to 0.13 per km. (about 1 in 10,000). It is circular in section, 2.10 m. (6 ft. 11 in.) diameter, with siphons consisting of two conduits of 1.10 m. (3 ft. 7 in.) diameter. It ends in Paris at the Montsouris reservoir, having two floors, one above the other, the overflow being at an elevation of 80 m. (262 ft.). The most important civil engineering works are the large siphons of the Yonne, the Loing and the Essonne, the arches in Fontainebleau forest, and the bridge aqueduct of the Bievre, the arches of which are above the old Arcueil aqueduct.

The Avre Supply.—The Avre supply, opened in 1893, delivers to Paris by gravity alone, the water from the sources of the Bigne, which take their rise in the Rueilla-Gadeliere district in the Eure-et-Loir Department, together with the water from other sources in the neighborhood. These various sources proceed from a chalk formation. Their supply varies between 60,000 and 108,000 cub. m. (18,500,000 gal.) per day. The aqueduct has a length of 102 km. (63 miles), on a gradient varying from 0.30 to 0.40 per km. (about 1 in 3,000). It is circular in section, 1.70 m. (5 ft. 7 in.) in diameter. The siphons consist of two conduits 1 m. (3 ft. 3 in.) in diameter. The principal civil engineering works in connection with this are a number of siphons and the St. Cloud reservoir, the capacity of which is 300,000 cub. m. (66,000,000 gal.), in which the aqueduct ends at a level of 108 m. (354 ft.).

The Loing and Lunain Supply.—The Loing and Lunain supply, completed in 1900, delivers in Paris water which proceeds from the valleys of these two rivers, drawn off in the vicinity of Nemours and Montigny-et-Marne Seine, Department. The water comes from chalk formation. The work at the catchment area has been most carefully carried out and every precaution taken to prevent any contamination. The supply, which at first was 50,000 cub. m. (11,000,000 gal.) per day, has been gradually increased by drawing from other springs, and is now approximately 100,000 cub. m. (22,000,000 gal.). The water is collected in the two valleys by aqueducts which end at the Sorques pumping installation, equipped with steam, producer-gas and electrically-driven pump sets for delivering it at a level of 40 m. (130 ft.) into a main aqueduct. This latter starts in Fontainebleau forest, and over its whole length of 73 km. (over 45 miles), except in the vicinity of Arcueil, it adjoins the Vanne aqueduct, and, like it, ends at the Montsouris reservoir. It is circular in section, 2.50 m. (8 ft. 3 in.) in diameter; the siphons consist of cast-iron pipes 1.25 and 1.50 m. (4 ft. 1 in. and 4 ft. 11 in.) in diameter, having flexible joints, the most important being those of the Essonne and the Orge. The Bievre siphon is built up of steel plates, and is 1.80 m. (5 ft. 11 in.) in diameter. The aqueduct bridge of Arcueil forms part of this system.

The four sources of water supply thus briefly described deliver, therefore, a total of from 260,000 to 350,000 cub. m. (about 70,000,000 gal.) per day, according to the seasons.

The Paris Water Board has in hand a scheme for drawing upon the sources of the Voulzie and Durteint above Provins, in the Seine-et-Marne Department; the aqueduct would have a length of 50 km. (about 30 miles), it would join that of the Loing and Lunain, to which it would bring an addition of from 80,000 to 100,000 cub. m. (20,000,000 gal.) per day. Another scheme is being considered, which would consist in the delivery to Paris of 500,000 cub. m. (110,000,000 gal.) and later of double that volume per day, collected from the sand formations in the Loire valleys between the towns of Gien and Nevers. It is proposed to draw upon the water resources of that locality by means of shafts and to put down electrically-driven pump sets for delivering into two aqueducts 175 km. (108 miles) in length. In order to restore to the Loire an equal volume of compensation water, several large lakes would be formed for storage purposes in periods of high flood of that river; these lakes would regulate the river flow and the discharge from them would be utilized to generate electric current.

When the discharge from the present sources is insufficient, or when the water from some of them is not clear owing to storms, or again in the event of an epidemic breaking out in a catchment area, or in case of damage to an aqueduct, the potable water supply is made up by filtered river water. The filtered water proceeds from two installations, one on the river Marne, at St. Maur, described further on, and one on the river Seine, at Ivry, built in 1899 and extended in 1906. After filtration, the water is sterilized by ozone or by hypochlorite of lime, and is then pumped into the potable water supply system.

Raw Water Supply.—The raw water supply is assured by a number of pumping plants which draw from the Seine and the Marne, having a capacity of about 800,000 cub. m. (175,000,000 gal.) per day, and delivering into special reservoirs for distribution. A scheme the carrying out of which was stopped by the war, will increase the above volume of water by 125,000 cub. m. (27,000,000 gal.) per day, by the installation of further steam- driven pumps at the Auteuil works.

An Englishman's View of American Roads

From Municipal Engineering and The Sanitary Record, London.

A good many exalted claims are made as to the excellence of American roads, but these claims are never found by English visitors and observers to be justified. In the book "Across America by Motor Cycle," by C. K. Shepherd, just published, that author claims to be the first Englishman to cross the American continent from New York to San Francisco. For the greater part of the journey—just fifty miles short of 5000 miles—the roads exhausted the language of a singularly fluent speaker, and kept his teeth rocking in their sockets and his bones shaking in every joint. After being thrown off some 140 times, he stopped counting such normal incidents of the day's ride. "Somehow," he writes, "the Americans think they are great road builders"; and some stretches of road that he crossed were at least as good as he expected; but 95 per cent. or more of America's highways, he declares, are "what they are pleased to call 'natural gravel' or dirt roads." The farther he went the worse they became. In Missouri, after the rains, it was only possible to cover some 10 miles in almost as many hours by a combination of pushing, lifting, paddling, and bottom-gear driving, to be thrown at last by a deep furrow into the ditch at the roadside, breathless and exhausted. On one occasion, Captain Shepherd tried the railway track, but as he narrowly escaped being run down by a train, he did not repeat the experiment. In Kansas City he helped to pay his passage by contributing an inflammatory artory article on "Roads" to the Kansas City Star, which achieved for him a notorious reputation along the remainder of his route.

Harbor Improvements in Japan.—For the purpose of providing more port facilities to ensure the satisfactory development of the foreign trade of Japan, it was decided at a recent meeting of the National Harbor Improvement Commission to initiate a large improvement plan. According to information from official sources, the work will be spread over ten years starting from the fiscal year 1923. It is authoritatively stated that a sum of 6,583,200 yen for the first installment of the project, will be included in the budget of 1923.

$25,000,000 Bridge and Other Works for Sydney, Australia.—A bill is before the Australian Legislative Assembly authorizing the construction of a bridge across Sydney Harbor and works in connection with this undertaking, at a cost of £5,000,000.

Exclusion of Silt from Irrigation Works

New Type of Headworks Proposed for Irrigation Canals.

From The Engineer, London.

A work of considerable interest to hydraulic engineers, which has recently been contributed to the papers of the Punjab Irrigation Branch by Mr. F. V. Elsden, executive engineer, deals with the effect of silt on irrigation works and with the possibilities of its exclusion from the canals.

The author naturally draws a distinction between the fine silt brought down by many rivers that is positively beneficial in its effects on account of its properties as a fertilizer, and the coarse, sandy silt which is an unmitigated nuisance to both the canal engineer and the cultivator. It is, of course, this latter class of silt which it is the aim of every irrigation engineer to keep out of his canal system, and Mr. Elsden describes at some length the measures usually adopted for this purpose. His final conclusion is that there is little prospect of an improvement in the present unsatisfactory state of affairs so long as the canal headworks are constructed on the lines now generally accepted as correct, and he puts forward an alternative suggestion.

Silt Carrying Power of Streams.—"It is," he remarks, "a fact well established by numerous experiments made on the Sirhind canal that silt which is carried in suspension in a stream varies in both coarseness and amount in any vertical line, the finer grades and the lowest silt content being found in the upper layers of the water and the coarseness and amount increasing towards the bottom until the heaviest grades, which may in a torrential stream even consist of shingle and boulders, occur in the very lowest layers of the stream, being in fact rolled along the bed rather than carried in suspension. . . .

Water flowing in a stream owes its power to carry silt in suspension to vertical eddies set up perhaps primarily by the roughness of the bed. It is found that for the same velocity a shallow stream will carry more silt readily than will a deep stream, a fact which may be explained as due to the vertical eddies, which are caused by the roughness of the bed, decreasing in strength as they rise towards the surface of the stream.

"A further explanation has been advanced by Mr. F. W. Schonemann, in a paper presented to the Punjab Engineering Congress, 1916, wherein he suggests, after Dupuit, that the greater silt-carrying power of shallow streams arises from the rate of change of velocity along a vertical being greater in shallow than in deep streams, an explanation which in in complete agreement with the hypothesis above postulated; that power to carry silt in suspension depends on the presence of vertical eddies, for it is evident that an increased rate of change of velocity or, what is the same thing, a greater difference in velocity in a vertical plane between adjacent filaments of water, will result in more powerful vertical eddies being sent up, and ipso facto, in an increased potentiality to carry silt.

"It follows, then, that eddies capable of supporting silt may arise, not only directly from the roughness of the bed, but also from anything which causes an increased rate of change of velocity along a vertical."

The author goes on to suggest that such conditions as those just outlined must prevail in the neighborhood of the orthodox canal regulator, and that vertical eddies must develop as the water flows over the raised sill and carry comparatively heavy silt over from the river into the canal. In support of this contention he gives some calculations which show that it would be a physical impossibility in several typical cases for the canal to be supplied with only the surface layers of water from the river flume, although the actual outlet over the regulator is confined to the upper part of the stream section.

Regulator for Skimming Off Top Water.—What is required for canals of any but the most modest dimensions, is, Mr. Elsden urges, some form of headworks which, while permitting only a moderate velocity in the undersluice flume, shall insure the arrival at the regulator of sufficient top water to supply the whole volume of discharge required for the canal, and this can evidently best be secured by aligning the face of the regulator along the plane which receives a maximum volume of top water per foot run. This plane is obviously the plane perpendicular to the direction of flow in the undersluice flume, and it therefore becomes apparent that the best position of the regulator is such that the face is at right angles to the direction of flow in the undersluice flume, instead of being nearly parallel with it, as has been customary up to this time. The regulator must also have a raised sill, the level of which shall be the lowest level from which water can be drawn without admitting water which contains an excessive silt charge, and adequate means must be provided for the egress of the bottom water, which is not wanted in the canal from the undersluice flume.

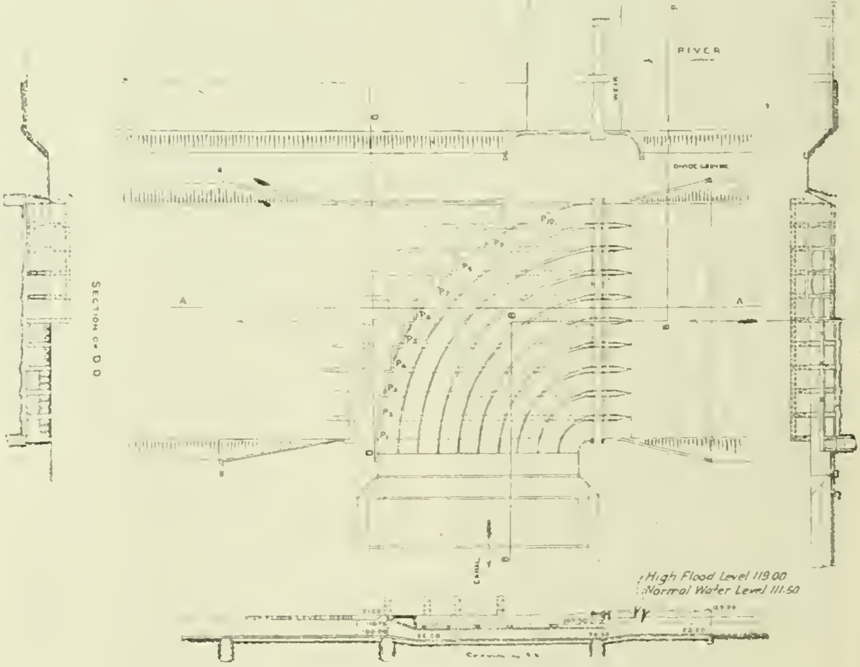


Fig. 1.—Plan and Section of Proposed Canal Head Regulator.

All this, Mr. Elsden asserts, points clearly to the necessity for the canal head regulator being super-imposed on the undersluices, the remaining features of the headworks, in general arrangement, being left much as they are at present designed, and the regulator sill being, say, one-third of the depth of flow below normal water surface level in the undersluice flume. In this way the top 3 or 4 ft. of the water flowing down the undersluice flume will be skimmed off and passed into the canal, while the water in the remainder of the depth will be passed with its silt, through the undersluices, and neither bottom water nor bottom silt will get into the canal.

Such a design naturally requires that a flow of surplus water be maintained in the undersluice flume, and it might be objected that there may not always be water to spare for this purpose. This objection, however, has no real weight, for when the supply of water is restricted it is most unlikely that it will be carrying a heavy burden of silt, and in such circumstances there will be no harm in closing the undersluices completely, for though this will entail the admission of bottom as well as top water, this bottom water will carry with it no silt which can do any harm. By this expedient of superimposing the canal head regulator on the undersluices, the supply of true top water to the canal will be maintained in a natural way, and there will be no turbulent flow due to sudden changes of direction. Twenty years ago such structure would have been somewhat difficult to carry out in at all a satisfactory manner, but the developments which have taken place in the use of reinforced concrete have much simplified the problem which does not now present any really serious difficulties.

General Plan of Skimmer Gate.—In order to show how it is proposed to carry out the design in practice, the author has worked out a general plan, which we reproduce in Fig. 1 of a canal head regulator based on the principles he has propounded. The regulator sluice gates are of an entirely novel design, and consist, as shown in the detail drawing in Fig. 2, of two parts—the sluice gate proper and what may be termed the skimmer gate—the latter being hinged at its lower edge, about which it can rotate upwards in order to adjust to varying water levels the height at which water is taken into the canal. This arrangement makes it possible to alter the level of the regulator sill while preserving a sharp cutwater against the current, thus reducing to a minimum eddies caused by the presence of the gate, and giving a gradual entry to the undersluice culverts.

It might seem that the skimmer gate could be used for the double purpose of regulating supply and adjusting sill height, and this would in fact be the simplest form of gate, but it is found that such an arrangement would involve either absurdly small spans or most inconveniently high pressures on the gate and its operating mechanism, and it will be more convenient in practice to admit pressure to both sides of the skimmer gate in order to lighten it and the standing gear for operating it. This can be most conveniently done by means of an ordinary sluice gate, the opening of which is so adjusted as to head up water on the down-stream side of the skimmer gate to a level little below that on its up-stream side.

How the Gates Can Be Operated.—Two ways of operating the gates present themselves. They might be operated by entirely separate gear, leaving to the regulating staff the task of adjusting the levels of the two gates, or, preferably, they may be interconnected, the standing gear which operates the skimmer gate operating also the sluice gate, and their relative motion being such that the amount of gate opening and the height of the skimmer gate are always in their correct relation. In this way the operation of the two sets of gates would be automatic, depending on correct design of the standing gear and not at all on the intelligence of the regulating staff, whose task would thus be limited to keeping the canal discharge correct, an operation which does not call for a high degree of intelligence or training.

Throughout the design care has been taken to make all cutwaters approximate to streamline form, and all changes of section of flow so gradual as to avoid as far as possible dissipation of energy and loss of head in unprofitable and avoidable eddy motion and interference with the silt regime of the length of stream before the supply for the canal is drawn off. It is to this that the unusual length of the pier noses is due. Water entering the canal is, at the moment of entry, flowing in a direction parallel with the direction of flow in the river and at right angles to the axis of the canal. It is therefore necessary to turn it through 90 deg. of arc as soon as possible after it enters the head regulator. Were the channel from the regulator to the canal proper left open over its whole width there would result a serious concentration of flow on the outer side of the curve, which would be attended by trouble in the canal, and for this reason the discharge of each bay of the regulator is dealt with separately, divide walls being provided to form a separate channel from each bay down to the point at which the direction of flow becomes parallel with the axis of the canal.

The arrangement of the undersluice gates in the usual way at the upstream ends of the undersluice culverts, besides being impracticable, would violate in certain circumstances the principle of gradual change of waterway, and these gates are therefore placed at the downstream ends of the culverts. It will be observed that the culverts are gradually enlarged at their down-stream ends in order to reconvert velocity bends into static heads and reduce to a minimum the amount of head which is totally lost in the passage through the culverts. The floor of the regulator, which is also the roof of the undersluice culverts, consists of a slab of reinforced concrete, which is peculiar, in that the worst loading to which it is liable to be subjected is in an upward direction, on the assumption that the canal is closed during a maximum flood. Double reinforcements is therefore needed, and this slab must also be tied down into the foundations of the structure by means of reinforcing rods passing down the piers and well into the foundations. The piers will therefore be of concrete, but should be faced with hard ashlar dressed to a smooth face in order to withstand wear and keep the coefficient of friction low.

The position of the canal head regulator superimposed on the undersluices makes it desirable to fix the lowest sill considerably higher than need be done in a regulator of the old type, in order to keep within reasonable limits the pressure to which the culvert roof will be subjected. At the same time the limit of heading up during a high flood cannot be indefinitely raised, and the result of these two limitations is that the type of head regulator advocated by Mr. Elsden will permit of less range of fluctuation in the water level above the weir than in the case of existing headworks. For this reason there can be no doubt that the most convenient form of weir would be one with its crest as low as possible, at the same elevation as the floor of the undersluice flume, and provided throughout its entire length with sluice gates which can be closed to maintain a sufficiently high level to feed the canal, or opened to permit a flood to pass without excessive heading up.

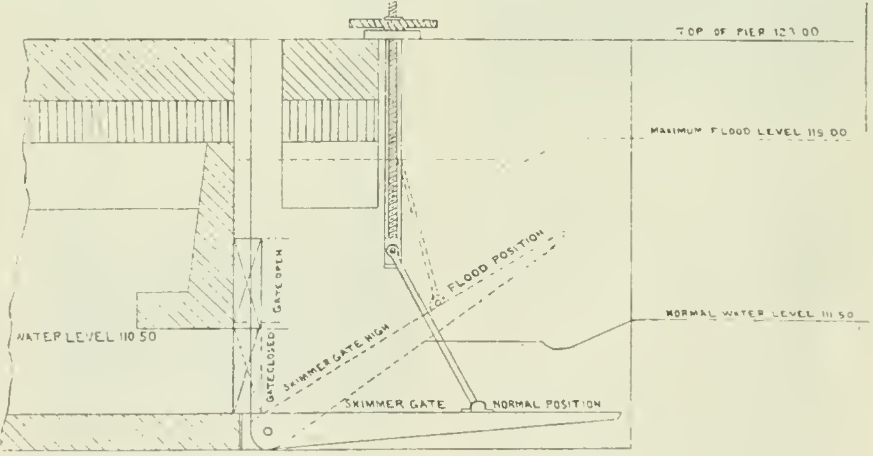


Fig. 2.—Arrangement of Proposed Canal Head Regulator Sluice Gates.

Cost of Proposed Headworks.—Some indication of the cost of the proposed type of headworks as compared with the current type is given by the author as follows:

The cost of the undersluices and head regulators will be considerably increased, and it is estimated for the example shown in the drawing to amount to Rs. 15,000,000, as compared with Rs. 9,00,000, which was about the cost of a regulator and undersluices of the ordinary type to suit the same conditions, showing an extra cost of Rs. 6,00,000. Coming to the weir, the cost for a weir of the ordinary type fitted with drop shutters was about Rs. 850 per lineal foot of waterway, or, in the example dealt with, Rs. 34,00,000, the waterway being 4,000 ft. long. For a low-level closed weir fitted with Stoney sluice gates throughout, the length of waterway being 2,400 ft. and the cost per lineal foot Rs. 1,200 complete, the total would be Rs. 28,80,000, or, in round figures. Rs. 29,00,000, showing a saving of Rs. 5,00,000, so that on the whole headworks the new type would cost about Rs 1,00,000 more than the old in relatively trifling sum, which Mr. Elsden declares could be well justified.

Effect of Road Surface on Haulage Cost.—In the appendix to a paper on road problems read before the Bloemfontein meeting of the South African Institution of Municipal and County Engineers, Mr. D. E. Lloyd Davies gave actual accounts showing the saving in haulage costs effected by the improvement of road surfaces. The savings ranged from 14.3 per cent in the case of a private motor car, through 16.4 per cent for a 4-ton lorry, to 22.2 per cent for horse-drawn traffic.

Motor Trains on Australian Railways

The motor train, a new feature on Australian railway lines, is at present enjoying a considerable amount of prominence. It is regarded as providing a solution of the problem of the hitherto embarrassing non-paying branch lines in the country districts. Experimental services have been in operation in both Victoria and New South Wales, and are said to have given complete satisfaction. The Railway Commissioners hope shortly to have in service in New South Wales a fleet of 20 rail motors of a type far superior to the experimental car on the North Coast, which is simply a converted motor car with a 40 H.P. engine. This new type is to be fitted with a 6-cylinder reversible engine of approximately 150 H.P., supported on springs under the center of the car.—The Engineer, London.

Insects as Aid to Sewage Purification

By F. W. HARRIS.
Corporation Chemist and City Analyst, Glasgow.

From Municipal Engineering and The Sanitary Record.

Preliminary tank treatment by sedimentation or chemical precipitation followed by biological filtration is the most widely adopted system for the complete purification of sewage.

The outstanding and most difficult problem in economy of working both contact and percolating filters has been the elimination of "surface ponding," which in proportion to the superficial area affected reduces the filtering capacity and efficiency of the filters and increases working costs.

The thin, slimy film which covers the surface of mature filtering media consists for the most part of disintegrated organic matter containing a teeming population of bacteria and innumerable forms of higher organism such as Protozoa, worms, etc.

Upon this slimy film there is constantly being deposited a product of the purification process—gelatinous organic matter—coagulated from the sewage applied.

Normally this gelatinous matter is ingested and finally oxidized by the organisms, but all too frequently this process appears to be overtaxed and the gelatinous deposit accumulates rapidly.

Misroscopical examination at this stage shows the presence of additional forms of life. On the microscopical field the disintegrated organic matter now appears to be deposited on the filaments or hyphae of fungal or algal growths. These filaments are so closely interwoven as to form a perfect network, a structure which accounts for the characteristic fibrous texture of the deposit.

The extending filaments soon span the interstices of the media, and with the coagulated organic matter deposited thereon a surface impermeable to both water and air is produced, causing "surface ponding."

Periods of rest was the original method adopted to restore the filtering capacity and efficiency.

In principle the method is a sound one, water constituting 98 per cent of the obstructing deposit. When air dried the deposit shrivels up into a mere fraction of its former bulk, but on restarting the filter it absorbs water and expands.

In practice we consequently find resting periods becoming more frequent, reducing filtering capacity and necessitating the provision of a larger filtering area, thus adding to the capital expenditure and increasing working costs.

These disadvantages are equally applicable to the practice of forking the media, while even the improvement following the more drastic and costly method of removing, washing, screening and replacing the cleaned media is not permanent.

The importance of a permanent solution of the problem of surface ponding both on the grounds of increased efficiency and reduction in expenditure, I need not emphasize and the possibility of maintaining the media of percolating filters in a permanently clean and open condition by the aid of insect life merits careful consideration.

The particular species of insect which has successfully accomplished this work is the Achorutes viaticus or water spring tails.

This small, wingless insect is widely distributed, but, unfortunately, its natural appearance on sewage filters is exceptional, Stratford-on-Avon, Kenilworth, and Nuneaton being the favored localities.

The practicability of cleaning the filtering media of percolating filters by the aid of Achorutes viaticus was first established at Stratford-on-Avon by Mr. H. D. Bell, now chemist and manager of the Barnsley sewage works.

Experiences at Glasgow.—During the winter months of 1920 one of the percolating filters at Dalmarnock ponded badly. In consequence I decided to investigate whether the character of the Dalmarnock sewage and the nature of the filtering media—whinstone—were suitable for the successful propagation of the Achorutes viaticus. For this purpose I had constructed at the works an experimental filter of 2 cubic feet capacity, and to provide facilities for studying the habits and activities of the insects I fitted up in the laboratory a large-sized conical-shaped vessel as an observation filter.

Both these filters were inoculated during January, 1921, with a supply of media, well seeded with eggs and thoroughly colonized, kindly forwarded by Mr. Bell.

My investigation has yielded valuable results, enabling me to overcome many local difficulties and disadvantages, to devise a simplified, improved and more efficient method of inoculating large filters, and thus facilitate success and extend the applicability of the method.

I have clearly established that successful colonization depends primarily on the thorough acclimatization of the insects to local conditions.

The experimental filter fulfills this purpose admirably, and its continuity is insured by my method of inoculation, which is based upon the fact that the filtrate from completely colonized media invariably contains small-sized insects.

The method is simple and its working demands very little attention. It is equally adaptable either for continuous inoculation or for direct inoculation of badly ponded sections, and provides a method of inoculating such sections with the minimum of disturbance to the inoculating media.

The method is also very economical in the use of colonized media, and renders the simultaneous and continuous inoculation of several filters a possibility.

Conditions favorable to colonization are more easily under control, and by the judicious application of suitable pabulum to the surface of the media in the boxes a condition of intensified colonization can be induced.

Since the adoption of this method in October, last, marked progress has been made notwithstanding the decidedly unfavorable local conditions as exemplified in the trades waste character of the sewage, the large-sized, smooth-faced media, and the exposed position of the filters.

Five of the percolating filters, representing a superficial area of 1.83 acres and a cubic content of nearly 25,000 yards, have been and are being successfully inoculated on the continuous system. The condition of the media all round the inoculations is now remarkably clean, and the activities of the insects are extending in every direction.

To those who decide to enlist these insects I would utter one word of caution. Do not anticipate an immediate disappearance of ponding. The method is not speedy. Patience and perseverance are required to attain success. Do not be discouraged if after inoculation you lose sight of the insects. They will be working below the surface, cleaning up the accumulation of years. The surest and most easily detected evidence of successful colonization will be found in the masses of white skin casts abundantly distributed throughout well-colonized sections.

From the results of my experimental work and practical experience I am convinced that these insects will become an important economic factor in the purification of sewage by percolating filters, and I confidently advise their utilization.

Railway Electrification in Chile.—A commencement is about to be made with the electrification of the Nitrate Railways Company's tracks, forming part of the principal railway system of the Province of Tarapacá, Chile. The first section to be taken in hand will be that of the Iquique-La Carpas, a stretch of about 17 miles, with heavy gradients. A preliminary estimate of the cost of the work is £2,000,000 ($10,000,000). The proposed work was covered by a contract entered into between the Nitrate Railways Company and the Chilean Government as far back as July, 1921. Owing to the opposition encountered in the Chilean Congress, which resulted in a declaration of nullificatfion of the contract, initiation of the work had to be suspended. The Nitrate Railways Company has always contended that, so far as it was concerned, the contract remained in force, and it intends to give it effect.—The Engineer, London.

Aeroplane Surveys in India.—It is understood, says Indian Engineering, that at the end of the current year or at the beginning of next year, an experimental air survey of a portion of the Irrawaddy delta is to be carried out by the joint efforts of the Public Works, Survey and Forest Departments. The latest map of this part of the country is based on a survey taken so far back as 1869, and is admittedly inaccurate. The work of surveying, in the ordinary way, such an area, fretted as it is with innumerable creeks, is of great magnitude. Climatically and physically, the Irrawaddy delta is especially suitable for aerial survey. About 700 square miles have been selected for the experiment and the work, which will be undertaken under the direction of the Air Board of the Public Works Department of the Government of India, is expected to occupy about three weeks.

Sewage Treatment By Mechanical Agitation

Description of Bio-Aeration Units at Sheffield, Which Have Been in Continuous Operation Since November, 1921.

By JOHN HAWORTH.

General Manager Sewage Disposal Department, Sheffield.

From The Surveyor, London.

The plant has been developed after a long series of experiments commenced in 1912, and consists of the circulation or aeration tank, three retention chambers, three settling tanks, gauging chamber and motor house.

Aeration Tank.—The aeration tank is 201 ft. 6 in. long, 75 ft. 10½ in. wide and 4 ft. deep below the water surface and has a capacity of approximately 354,400 gal. It is divided into 18 longitudinal channels 4 ft. wide by thin division walls, with a transverse channel 2 ft. 3 in. wide by 6 in. deep along the end facing the retention chambers. The channels are rounded and connected at their ends so as to form one continuous channel 3,544 ft. in length. The transverse channel has been made deeper than the longitudinal channels, so as to admit of retention chambers of increased size.

The ends of the division walls forming the return of the channels are enlarged in order to strengthen the division walls and to reduce the eddies in the water flowing round them, and correspondingly the frictional head losses, and to produce changing surfaces of the liquid. The floor of the tank is flat, and the channels are therefore rectangular in section.

Across the center of the tanks are arranged eighteen paddle wheels, referred to later, which agitate and circulate the water.

Inlets for the Sheffield and Tinsley sewage are provided, the former being fitted with a float regulating valve. The outlet from the tank is over the weir wall running the full length of the transverse channel and forming one side of the retention chambers.

The mechanical operation of the aeration tank consists in creating rapid surface changes of its contents by means of the paddle wheels, which agitate the liquid and circulate it continuously round and round the channels, the rate of outflow from the tank being governed by the rate at which the sewage is let into it.

Retention Chambers and Settling Tanks.—The retention chambers are triangular in section, the wall adjoining the aeration tank is vertical, and, as before stated, the liquid enters the chambers by passing over it. The opposite wall is sloping, and at the top of this is formed the weir over which the liquid discharges into the feed channel to the settling tanks. In the bottom of the vertical wall are openings through which any sludge settling in the retention chambers may return to the aeration tank. The chambers are 4 ft. 3 in. wide and 4 ft. 8 in. deep, and correspond in length with the settling tanks.

The object of the retention chambers is, by the greatly diminished velocity of flow obtained in them, to secure partial settlement of the liquid before it passes to the settling tanks, and so "retain" as much sludge as possible in the aeration tank.

This advantage is three-fold; it reduces the amount of sludge to be pumped, less sludge reaches the settling tanks and thereby their settling capacity is increased, and there is less sludge temporarily out of action.

The three settling tanks are of the Dortmund type, pyramidal in shape, with sides sloping 1 to 1½; they are each 24 ft. sq. by 21 ft. 6 in. deep, and have a total capacity of 102,600 gal. The liquid enters each tank by a 12-in. penstock and pipe which connects to a plain vertical bottomless box 4 ft. square inside and submerged 7 ft. of its length in the liquid. The boxes and the ends of the pipes bolted to them are supported centrally in the tank by trussed beams and built of light steel angles and flats. The four sides of each tank form the weir over which the effluent passes to the collecting channels, or direct to the gauging chamber, where the flow is registered by a "Lea" recorder. From the chamber the effluent empties into the discharge culvert to the river.

The sludge from the settling tanks is raised by hydrostatic pressure through 6 in. pipes into small sludge chambers in which the control valves are fixed. In each of these chambers are also two small pilot pipes fitted with valves, by means of which the attendant is able at any time to check the level or amount of sludge in the tanks. From the sludge chambers the sludge gravitates through a stoneware drain to the sludge well below the motor house, whence it is pumped back to the aeration tank, entering the channel furthest from the motor house where a "Lea" recorder registers the amount of sludge pumped. On the sludge return main and near the motor house there is a by-pass valve and chamber through which the surplus sludge is evacuated to the land.

General View of Sheffield Bio-Aeration Plant.

Motor House Equipment.—The motor house is 24 ft. long by 16 ft. wide and contains two 20-b. h. p. motor belt-connected to worm-reduction gears which in turn drive the two shafts on which the paddle wheels are fixed. The layout is so arranged that each worm gear can be driven independently by its own motor, or the two gears can be coupled together and driven by one motor, the other motor then becoming a stand-by. Each motor is equipped with a liquid starter.

It is admitted that the belt drive does not give the most efficient power unit, but it was specially introduced for experimental purposes, so that, by varying the size of the belt pulleys, different speeds of the paddle wheels could be obtained.

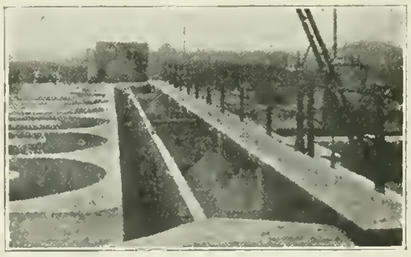
Below the motor house floor are the sludge and pump wells. In the latter two 4 in. centrifugal pumps direct coupled to 7½ b. h. p. motors are installed. These motors are controlled by a float in the sludge well and an automatic relay switch or by hand. The sludge well has a capacity of 2,500 gal. at invert level of the inlet pipe.

Aeration Plant Showing Paddle Wheels and Motor House.

All necessary instruments for recording the power consumed are provided on the switchboard in the motor house.

The electrical supply is 3-phase alternating current 50 cycles per second and 440 volts.

Aeration Paddles.—Referring to the paddle wheels, these are 10 ft. in diameter by 2 ft. 6 in. wide over all, constructed of light steel angles suitably braced and connected to cast iron split bosses which are bolted and keyed to the shafts. Each wheel weighs about 7 cwt. There are eight arms to each wheel, and each arm presents a blade surface to the water of 227 sq. in., with a radius gyration of 3.66 ft. about the paddle wheel shaft.


Retention Chambers Under Construction.

At 15 revolutions per minute of the paddle wheels a minimum velocity of flow of 1.7 ft. per second is secured in the channels of the aeration tank. Several experiments have been made by increasing the blade area of the wheels and reducing the revolutions per minute, and it was found that at any speed less than 13 revolutions per minute—whether the blade area was increased or not—a considerable wave effect on the water was produced which caused splashing over the walls at the curved end of the channels. If it be advantageous to secure this effect from the point of obtaining greater aeration—which has yet to be

Aeration Tank End and Settling Tanks.

proved it will be necessary to increase the height of the walls at the channel ends.

The installation occupies the site of part of one of the existing storm beds, and covers an area of less than half an acre. The work was carried out by departmental labor, and cost £12,000.

Operation of the Aeration Tank. In its operation the aeration tank may be compared to a river containing a very large number of oxidizing organisms capable of purifying putrescible matters. To this river or stream sewage is added in such volume as it is able to purify continuously. A proportion of liquid is being continually taken from the stream at a point remote from the inlet and equal in volume to that of the sewage which is being added. This portion passes to the settling tanks, where the purified liquid and sludge are separated.

The aeration tank was filled with sewage on Nov. 4, 1920, and about 40 tons of sewage sludge and humus collected from contact beds, etc., were thrown in. After about 21 days' circulation the sludge had become matured and was found to contain ample biological life.

On Nov. 26, 1920, sewage was admitted and one settling tank put into operation, the other two being started a few days later. From this date effluent has been discharged continuously with the exception of a few odd days occupied in minor alterations and adjustments.

The sludge or humus has been allowed to accumulate in the tank to the extent of about 25 to 30 per cent, any excess being periodically discharged onto a land filter.

Scheme for Future Extensions.—This scheme provides for the conversion of 24 contact beds (½ acre each) into 12 bio-aeration units capable of dealing with a dry-weather flow of sewage of 15,000,000 gal. per day and up to three times this volume in time of storm.

In 1905 the Local Government Board sanctioned the present works of settling tanks and primary contact beds as an instalment of what would eventually be necessary on the corporation undertaking to add works for secondary treatment later. The scheme for secondary treatment was approved by the Local Government Board in 1914, but owing to the war this work has not been carried out.

Since 1914—that is to say, during the last six years—extensive experiments on a practicable scale have been carried out by the Sheffield Corporation on the treatment of sewage first on the diffused air method and later by mechanical agitation and surface aeration, and in 1920 the large unit on the latter system already described was constructed by the corporation as a charge to revenue.

In lieu of proceeding with the secondary treatment scheme, as recommended in 1914, the corporation has decided to adapt the bio-aeration system.

Each of the 12 units will have an average treatment capacity of 1,250,000 gal. (D.W.F.) per day, and will consist of one aeration tank and a series of nine settling tanks.

To each four units there will be one motor house containing four motors and reduction gears for driving the paddle wheels, and to each eight units one pump house containing six motors and pumps for returning the sludge and evacuating the surplus sludge.

It is estimated that each unit will take about 40 to 45 b.h.p. including pumping.

All recording instruments for gaging the volume treated and other equipment to make the scheme complete will be provided.

Current for driving the plant will be obtained from the corporation power station adjacent to the site on a maximum demand rating of ¼d. per unit plus certain K.V.A. and other charges governed by the price of coal, which at the present time brings the total rate to approximately 7d. per unit.

So far as Sheffield is concerned this scheme will involve half the capital outlay of any alternative proposal giving equal purification results, and occupy about one-sixth the area of land, while the estimated working costs in either case will be about the same.

The estimated cost of the scheme is approximately £250,000 if carried out during the next few years.

The Costs.—Working costs including maintenance based on the actual costs of the unit now at work and at present prices would be approximately as follows:

	Per million d.w.f.
For a plant to treat 1,000,000 gal. per day and to take storm water to 3 d.w.f.	£4 4 5
For a plant to treat 2,000,000 gal. per day	£3 10 9
For a plant to treat 5,000,000 gal. per day	£3 0 6

In considering these costs with those for treatment of filters, depreciation in capacity and cost of renewal media has been neglected. These factors make a considerable increase in working cost which is often overlooked.

New Dredge Has Four Complete Bows

From Times Engineering Supplement, London.

A cutter suction-pump reclamation dredger of unusual form, the hull having four complete bows, has been launched at Renfrew by Williams Simons & Co., for the Government of India.

Designed for opening up new waterways and improving the depth of shallow canals or rivers, the Cowley, which is to be used in dredging the shallow rivers in the Province of Bengal, is able to cut a canal or channel about 45 feet wide at bottom in one cut. Suction frames are led through the three open wells erected at the fore part of the ship by the formation of the bows, and each of them has two suction orifices carrying two rotary cutters arranged to work in advance of the suction nozzles for disintegrating clayey material which would otherwise be unsuitable for suction pump dredging. Each pair of cutters is driven by an independent four-cylinder tandem compound engine through spur and bevel gearing. The suction frames are designed to dredge to a depth of 30 ft. under water, and are controlled by steam hoisting gear and wire-rope tackle in such a way that they may be raised or lowered independently or conjointly as required.

The two centrifugal dredging pumps are each driven by an independent set of vertical triple-expansion engines and deliver the material dredged direct through a floating pipe line 600 ft. long and 42 in. in diameter, made up of twelve 50-ft. sections carried on twelve floating pontoons and coupled together by socket and spigot connections. The pipe line is raised by a terminal pontoon to a height of 25 ft. above water level, and the dredged material is finally discharged over the canal bank to a distance of 150 ft. from the center of the terminal pontoon. The dredger will be propelled at eight knots by means of three propellers, each driven by a separate set of vertical compound surface-condensing engines.

Another dredger, of the suction cutter hopper type, which has been launched on the Clyde by Ferguson Brothers, Port Glasgow, is for the Union of South Africa Government, and is intended for use in deepening Durban harbor. The Oceanus, as she is named, will dredge in stiff clay to a depth of 50 ft. below the water-line, at the rate of 2,000 tons an hour, and she has pumping capacity sufficient to discharge the material through 2,500 ft. of piping. The main suction pipe, the lower end of which is fitted with a heavy steel cutter, is carried in a movable frame in the well. As an alternative to discharge through the pipe line, the dredged materials may be discharged through the bottom doors of the hopper. The vessel, which is 303 ft. in length, is propelled by twin-screw, triple expansion engines obtaining steam from three Scotch boilers.

Ancient English Roads and Their Development.—The following notes, culled from a lecture given by Mr. G. H. B. Ward at a Sheffield library, are interesting: The problem, said Mr. Ward, when our road system was being completed between 1818 and 1830, was to make them sufficiently strong to carry the very heavy traffic, such as the coach-and-six and the heavy miller's wagon. One thing our forefathers did was to exempt certain of the tolls where the wheels of the vehicles were over a certain width. Wheels of tremendous width were prevalent in those days, and the roads were to some extent flattened down by this type of vehicle as they went along. The history of English roads was scanty, and save for reference to medieval deeds and charters very little was known before the seventeenth century. Apart from trunk roads and principal cross-roads, the modern turnpike, as we know it today, was largely made between 1750 and 1830. Macadam and Telford were late eighteenth century inventors, and the modern cross-roads were almost completed as the first railway engine began to puff along the iron road in 1830.—Municipal Engineering, London.

Congress of Canal & Dock Engineers.—A congress of the leading shipbuilders, canal, waterway, and dock engineers will be held in London in July, 1923, under the presidency of Lord Desborough. Delegates from at least 24 countries are expected. Amongst the questions which will be discussed are: Utilization of waterways for the production of power, port works in relation to the future dimensions of ships, loading and discharging equipment, etc. The opening day has been definitely fixed for July 2.

A 168,000 H.P. Hydro-Electric Project in Italy

From The Engineer, London.

The growing industrial demands for power in the south of Italy point to the utilisation of some of the larger water powers, and a very important financial group, Societa Meridionale di Elettricita, initiated by Comm. Maurizio Capuano, the Chairman of the Sila Company, working in conjunction with the Banca Commerciale Italiana and with the Societa delle Strade Ferrate Medridionali and other financial houses in which Vickers, Limited, are interested, is now promoting a scheme for the supply of electricity to Puglia, in Southern Italy, and of water for irrigation purposes to the Important districts around and north of Cotrone. The Pugliese Electric Company will transmit the power via Taranto in Publia, to the provinces of Lecce and Bari. It is proposed eventually to supply energy to Sicily.

The River Neto affords excellent opportunities for hydro-electric development, and it is proposed to obtain from it a total of 168.267 h.p., while water for irrigation purposes will be supplied to the agricultural land on the lower reaches of the river, thus bringing into irrigation an area of about 24,700 acres. The project entails the harnessing of the upper water of the Neto, and its two important tributaries—the Arvo and the Ampollino—by the construction of storage reservoirs on these rivers, and the leading of the regulating discharges to power houses situated lower down the valley.

The reservoir on the river Arvo will have a top water level of 4223 ft. above sea-level. The masonry dam impounding the water will be built across the stream close to the village of Nocella. The dam will be abont 130 ft. high and about 900 ft in length, while the reservoir capacity will be about 34,540,000,000 gals. The stored water from this reservoir will be led through a tunnel of about 3 1-3 miles in length to the Ampollino reservoir. The latter will be formed by constructing a masonry dam 102 ft. high and 450 ft. long across the Ampollino River close to Trepido. The top water level of the reservoir will be 4,176 ft. above sea level, and the capacity impounded will be 13,420,000,000 gal. The total capacity of these two reservoirs, 47,960,000,000 gal. will form the main storage of the proposed scheme, and will yield 85,800 gal. per minnte—as a continuous discharge.

Taking off at an altitude of 1,250 m. above sea level from the Ampollino dam, a tunnel will be constructed through the hillside to a point directly over the proposed upper power station, the length of the tunnel being about 4,395 m. At the outlet end of the tunnel will be constructed a surge tank, and a pressure forebay for the pipe line. The power station will be bnilt close to the river Neto, where a gross head of 597 m.—1,958 ft. 9 in.—will be available. The upper reaches of the river Neto will be tapped by means of a small reservoir formed below S. Giovanni, by building a dam 62 m.—just over 200 ft.—high and 190 m.—623 ft.—in length across the river, thus impounding about 17,000,000 cubic metres— 3,740,000,000 gal. The reservoir will not be large enough wholly to regulate the flow in the river, bnt its regulating action, combined with the natural flow, will yield 8.5 cubic metres per second—say, 112,200 gal. per minnte—as a continuous discharge. A tunnel 6,945 m. in length will lead from the reservoir and will emerge opposite the proposed power station already mentioned. The whole of the machinery will be concentrated here, that portion of. it deriving its water from the Neto working under a gross head of 117 m.—say, 384 ft.

Owing to the favorable configuration of the ground, it will be possible to utilise the tail waters from this upper power station to the extent of 15 cubic metres per second—198,000 gallons per minute—by constructing a canal and tunnel of 3,565 m. in length, to a point further down the river, where a gross head of 404 m. will be available. It is proposed to construct here a second intermediate power station, where 80,960 horse power will be developed. By a further development lower down the river, again utilizing the tail water from the intermediate station, a third power station can be constructed capable of yielding 20,080 horse power under a head of 100 m.

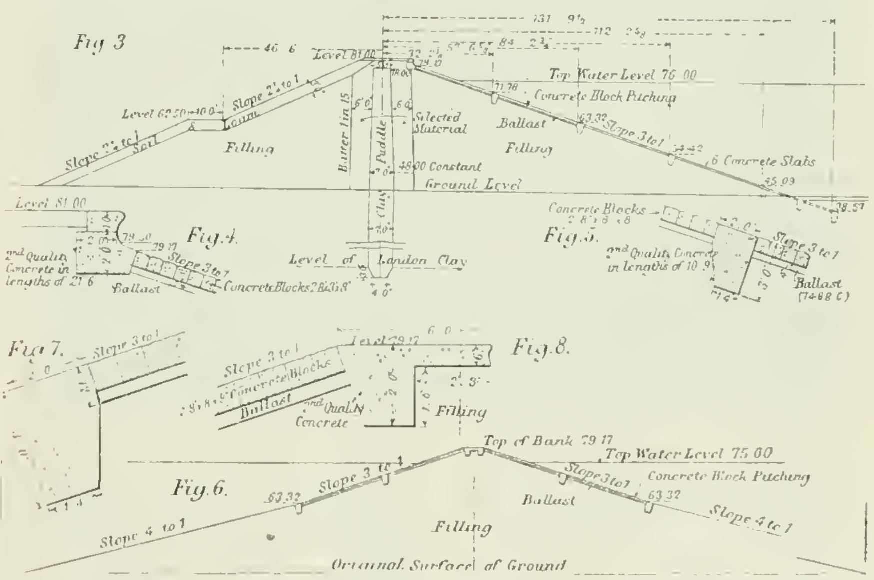
The project is one which can be developed in stages, according to the industrial requirements for power, and the well-known Italian hydro-electric engineer, Signor Angelo Omodeo, of Milan, who has prepared the scheme, has kept this very important point in view when making his proposals.

Earth Embankment and Baffle Bank of Littleton Reservoir of London

From Engineering, London.

The largest single enterprise which the Metropolitan Water Board of London now has on hand is the construction of the Littleton service reservoir.

The reservoir will have a water surface of about 723 acres and a capacity of approximately 6,750,000,000 gal. This is supposed to represent the largest storage reservoir of its kind ever constructed.



Figs. 3-8.—Details of Embankment and Baffle Bank of Littleton Reservoir of London Water Supply.

The water, which will be drawn from the Thames, will be used to supplement supplies to both North and South London. Part of the supply will be discharged into the existing Staines Aqueduct, which passes close to the north side of the new reservoir. The remainder will be led in the direction of Kempton, where part will be drawn off at the Board's works there for the supply of existing reservoirs and filters and of new filters installed there. This supply will be delivered to the north of London. Beyond Kempton Park one conduit from Littleton will carry water to the Hampton water works, for filtration and distribution.

Originally the plan of the reservoir covered ground extending rather further west and not so far south. Two baffle banks were also included with the idea of securing good circulation. When the present contract was well under way, however, it was found that it was advisable to modify the form of the reservoir to some extent. The main embankment is being constructed of earth with a core of puddle clay carried down and tied into the London clay, which extends over the whole area below the top alluvial deposits which consist of good ballast of a quality suitable for concrete. On the western side of the original lay-out, however, it was found that a greater depth of running sand than was originally contemplated existed above the London clay, on the line of the puddle trench. It was consequently decided to set back this side towards the east, and carry out extension towards the south so as to maintain the requisite capacity. As a result of this modification it became necessary to provide only one baffle bank to deflect the flow of the water from a direct course between the inlet and outlet. This would naturally have been placed approximately in the center of the reservoir, but as the banks originally planned were already under construction, it was decided to retain one of these, i. e., the eastermost, omitting the one to the west.

Sections of the embankment and baffle bank are given in Figs. 3 to 80. The main embankment is shown in Fig. 3, which shows the puddle core reaching to the London clay into which it is carried to a depth of at least 3 ft. The maximum thickness of the core is 7 ft. and this tapers to 5 ft. at the top of the embankment. On either side of the puddle wall is arranged selected material for a width of 6 ft., the remainder of the bank being ordinary filling. On the water side the slope of the embankment is 3.1, and on this side it is faced with slabs and block pitching. Slab facing is carried from 63.32 O. D. down to 38.57 O. D., that is 4 ft. below normal ground level, the bottom of the reservoir being at 37.0 O. D. The slabs are 6 in. thick and are held in place on the slope by keys or footings of concrete 3 ft. deep by 1 ft. 4 in. at the bottom and 2 ft. wide at the upper surface. The upper part of the slope is faced with concrete blocks, 2 ft. 8 in. long by 8 in. laid on 4 in. of ballast, the vertical joints between blocks being broken and left ¼ in. wide. This blocking is also held in place by similar footings, a detail being shown in Fig. 5. The coping, a detail of which is given in Fig. 4, is of concrete and is finished with a reversed curve to throw back waves. The width of the bank at the top is 14 ft. The outside slope is 2¼ to 1, a 10 ft. berm running round the whole at 62.5 O. D. level. The outside slope is finished with 3 ft. of loam, and will be grass covered and planted with shrubs. Most of the puddle trench has been excavated by grab bucket. Fig. 9 shows part of the battery of pug mills. The clay is brought to the elevated platform of pug mills in side-dumping cars, passed through the mills and shoveled into other trucks on a lower level. At the trench, blocks of clay are slid down chutes to be stopped by a man standing on a baulk spanning the trench.

Details of the baffle bank are given in Figs. 6 to 8. This wall has no core and consists simply of earthwork protected for the upper portions of the slopes by concrete block pitching laid on 4 in. of ballast. The top is laid with 6 in. of slab concrete to a width of 6 ft.; at the two edges the concrete is increased to a depth of 2 ft. in the manner shown in Fig. 8. The concrete footings holding up the block pitching are 3 ft. deep as in the case of the main embankment. The upper pitched portion of the slope is 3 to 1, the lower portion, permanently below water level, is unpitched and 4 to 1. The top of this bank will be approximately 4 ft. above the highest water level.

Irrigation in India

From the Triennial Review of Irrigation in India (1918-1921).

Forty-five years ago the area irrigated by State works was under 10½ million acres, while in 1919-20 it was 28 million acres. Work under construction will add 2½ million acres, and projects submitted to the Secretary of State for sanction are designed to contribute another 4¾ million acres. Thus a total eventual area in British India of 36 million acres is contemplated from works existing, sanctioned, or awaiting sanction, irrespective of the natural expansion of existing areas and of new projects not yet submitted to the Secretary of State.

The total capital invested in the works amounted in 1920-1921 to Rs.-7,861 lakhs, at present rates of exchange equivalent to about 52½ million pounds ($250,000,000), though much of it was raised when exchange stood higher. Taken as a whole the revenue from irrigation yields a return on the capital of from 7 to 8 per cent. This is the more satisfactory since over half the outlay has been on "protective works" which were not expected to pay their way, and which give an average return of less than 1 per cent. The capital sum also includes expenditure on a number of large works under construction which have not yet begun to earn revenue. The net revenue on productive works in 1920-21 was 8.88 per cent.

Concrete Road Construction at Manchester

English City Builds 8 Miles of 40 Ft. and 50 Ft. Paved Highway to Provide Work for Unemployed

By J. L. MEEK.

From The Engineer, London.

Two years ago, in the latter part of 1920, it became necessary to find work for the unemployed in the Manchester district, and in considering the most suitable kind of work to meet the emergency, the Corporation favored the construction of some arterial roads that had been already decided upon under town-planning schemes, as being work which could be put in hand at once, and which would provide employment for the largest amount of unskilled labor. The majority of the roads on which it was decided to commence work were either 100 ft. in width between fences or 80 ft. in width between fences. The town-planning scheme provided that the 100-ft. road should consist of two carriageways, each 20 ft. in width, a center space of 28 ft. to be reserved for a double line of tramway fenced off from the two carriageways, but with suitable crossing places for vehicular traffic arranged at frequent intervals, and two 16-ft. footpaths.

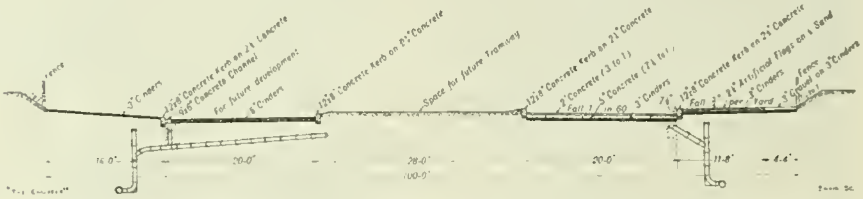


Fig. 1.—Cross Section of New Road Being Constructed Near Manchester.

Roadway Designed for 10-ft. Traffic Widths.—The 80-ft. road was to consist of a 50-ft. carriageway and two 15-ft. footpaths, as it was considered unlikely that any tram service would be required on these roads. The actual form of construction of these carriageways and footpaths was not finally decided under the town-planning scheme, as it was considered unlikely that any of these roads would be constructed in the then immediate future, and, in view of the many improvements constantly taking place in road construction, it appeared unwise to draw up a hard-and-fast specification for work that would in all probability not be carried out for many years to come. The width of the footpaths was not altogether influenced by the requirements of pedestrian traffic, but also by the desire to make them wide enough to take all the usual underground services, and so avoid the frequent taking up of the carriage-ways consequent upon services being laid under them. The carriage-ways were designed to take lines of traffic in multiples of 10 ft., it being thought, from observations of present-day traffic and with reasonable allowance for future traffic, that 10 ft. would be an ample width for a traveling vehicle to occupy.

When it was decided to commence the construction of several of these roads at once to find work for the unemployed, the question of the actual make-up of the roads was influenced by the necessity of spending as much money as possible on labor and as little as possible on material. It was therefore decided in the case of the 100-ft. road to complete all excavation and filling to formation level for the full width of the road, but only to pave one carriage-way and one footpath, so that the public might use the roads when completed, leaving the other carriage-way and footpath ashed and rolled until such time as the traffic justified a permanent paving or such was rendered necessary by development taking place in the vicinity of the roads. The center portion of the road was simply left at formation level. Fig. 1 shows a cross section of the roads as they are being constructed at the present time. On only one of these roads were both carriage-ways paved. This road passes through a large housing estate. In the case of the 80-ft. roads, the whole of the 50-ft. carriage-way is paved, as also are both footpaths. If only a portion of this road had been paved, it would have been an awkward matter to separate the paved portion from the unpaved portion, as no natural division existed like the tramway track on the 100-ft. road.

Some little time previous to the commencement of these roads, the Corporation had laid down a concrete road in another part of the city in six experimental lengths, and the behavior of this road for the short time it had been under observation seemed to indicate that a concrete surface would be successful in the case of these new roads, and it was accordingly adopted, but as a precaution the levels were so arranged that should the concrete surface prove unable to withstand the traffic, another wearing surface could be superimposed on it.

Speaking generally, these roads are not reinforced concrete roads, as reinforcement has only been used in the case of bad foundations or on embankments or where trenches had recently been opened across the roads to provide connections for the services from one footpath to the other. All departments controlling underground services, such as water, gas, electricity and telegraphs, were asked to put in any crossings they might require under the carriage-way before it was concreted and reinforcement was used over these recently filled-in trenches.

Method of Constructing Pavement.—The method of constructing the concrete carriage-way in all the roads was identical, despite the variation in width, and therefore a general description will suffice. Where there was a sound foundation, capable of supporting from 30 cwt. to 2 tons per square foot, which was generally the case, the method of constructing the carriage-way was as follows: Three inches of ashes or clinkers were rolled and consolidated on the natural foundation to form a bed for the concrete. On this bed, after well watering, the concrete was directly placed. The total thickness of the concrete was 7 in. laid in two courses, the bottom course being 5 in. in thickness and the upper course 2 in. in thickness. The proportions of concrete for the bottom course were approximately 5 parts of stone, 2½ parts of sand, and 1 part of Portland cement, while for the top course they were 2 parts of stone, 1 of sand and 1 of Portland cement. It will be noticed that these proportions are stated to be approximate, as the voids in the stone were measured frequently during the course of the work and the proportions adjusted accordingly to obtain as dense a mixture as possible. The variations from the proportions mentioned proved, however, to be very slight. The stone in the bottom course was a good hard stone, obtained from districts as near to Manchester as such stone could be found, and was from 1½ in. to ¼ in. in gauge. The sand for this course, which was also obtained locally, was clean and free from organic matter, but was not very sharp. The stone for the upper course consisted of approved granite, ¾ in. to ¼ in. in gauge, while the sand was thoroughly good, sharp sand or granite grit. The Portland cement throughout had to comply with the British standard specification. By adopting this two-course method of construction, a long railway haul was avoided for the majority of the material, and a thoroughly sound granite wearing surface was provided. All the concrete was hand mixed and deposited in alternate bays of about 14 ft. in length. When concreting started on a length of road, one gang proceeded to lay alternate bays, and in about ten days or a fortnight another gang followed along filling in the bays that the first gang had omitted.

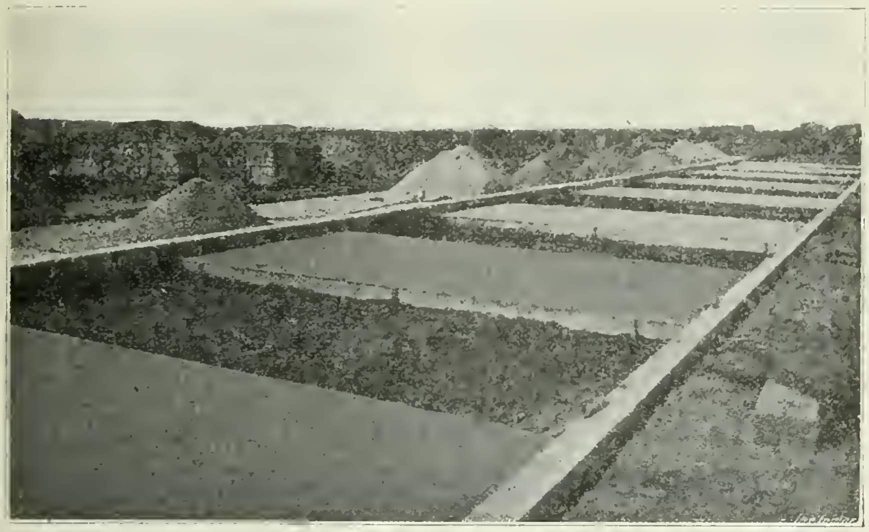


Fig. 2.—Method of Construction in Alternate Bays.

In laying the concrete, the top and bottom courses were placed in position practically simultaneously in order that the whole thickness of concrete might set together in one homogeneous mass, and when once concreting had been commenced on a bay, no cessation of work was allowed until the bay had been completed. The upper surface of the concrete was finished off to the required levels and falls with a wooden or steel-shod template. No trowelling was done. The cross fall adopted was 1 in 60.

Where cross trenches had been recently excavated in the carriage-way foundation, single-mesh reinforcement was used, care being taken that the reinforcement had a good hold on each side of the trench in the concrete resting on the solid ground. This type of reinforcement was purchased from various makers who manufacture this class of material.

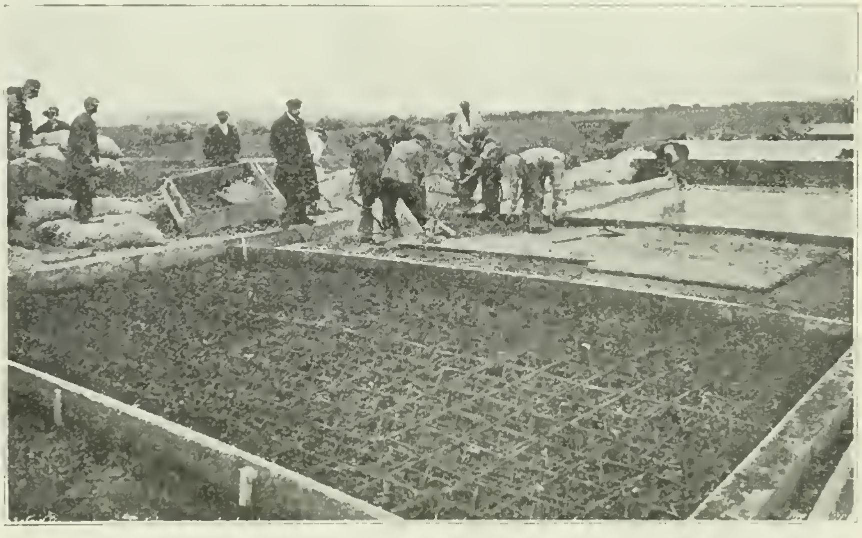


Fig. 3.—Reinforced Section Under Construction.

Construction on Embankment.—The roads were constructed with the approval of the Ministry of Transport, and with the assistance of grants-in-aid, either from that Ministry or from the Unemployment Grants Committee, and a date for completion was stipulated for some of the roads, while it was recognized for all of them that it would be advisable to complete them as soon as possible. This meant that in the case of embankments little time would be available for them to settle before they had to receive a road surface. In the case of high embankments and bridge approaches, it was recognized that no form of concrete surface would be suitable, and accordingly a tar-macadam surface will be laid down until such time as these banks have become thoroughly consolidated. In the case of the smaller embankments, however, it was felt that some effort should be made to avoid breaking up the continuity of the road surface, and accordingly a reinforced concrete road was laid at these places.

The banks were first consolidated by watering and rolling, and the reinforced concrete structure placed on the well-rolled foundation of ashes. As these particular sections of road would be called upon to distribute the weights of the traffic exactly as any other form of foundation raft would be, it was recognized that they must be reinforced in a similar manner, and provision be made for tension in the top and bottom surfaces, and also for shear. For this purpose the Walker-Weston Company's reinforcement, which makes provision for these stresses, was used. The depth of these reinforced portions is 9 in., and the carriage-way is extended for 1 ft. 6 in. under the curb at each side of the road to give support to traffic traveling close to the curb. The reinforced sections are constructed in bays as are the ordinary sections. An inch of concrete is first laid, and on this the reinforcement, 6 in. in depth, is at once placed, and the concrete well worked round it with 2 in. of concrete between the upper surface of the reinforcement and the finished road surface. This concrete consists entirely of granite and sand of good quality, the proportions and sizes of stone being the same as on the other portions of the roads.

Special Construction Through Peat Bog.—One length of 80-ft. road passes for a mile through a peat bog, varying in depth from 5 ft. to 10 ft. below formation level. The peat is taken out for a depth of 1 ft. 6 in. below formation, and this space is then filled in with ashes and clinkers and rolled with rollers of varying weights from a light horse roller to a heavy steam roller, more ashes being added as sinkage takes place. In some places the ashes alone cannot be made to support the weight of the rollers, and in these cases wattle hurdles are placed on the peat below the ashes. When the ashes have been so consolidated that they will bear a weight approaching 2 tons to the square foot without undue depression occurring under the wheels of the rollers, reinforced concrete slabs are constructed on the ash surface. Each slab is continued for a width of 2 ft. 6 in. beyond the curb, and is thus 55 ft. in width by 14 ft. in length. The method of construction by alternate bays is similar to that adopted throughout the roads, but the thickness has been increased to 12 in. at the center and 9 in. at the edge of the road, the reinforcement being 9 in. in depth at the center and 6 in. at the outsides.

The surface of all concrete roads is kept damp for at least a week after the concrete has been placed, and in hot weather the surface is protected from the sun by wooden shades or pent houses on wheels that can be easily moved from bay to bay. In frosty weather the concrete is also protected from the effects of frost while setting.

Pre-Cast Curb, Fence Posts and Sidewalk Flags.—The curbs and fence-posts are manufactured in depots adjacent to the work, the fence posts being reinforced by four ¾-in. diameter steel bars. The paving flags for the footpaths are manufactured on the finished road surfaces and when matured are set on the footpaths. The curbs, fence posts and flags are of 4½ to 1 concrete. In order to test the density of the concrete, pieces were cut out for the full 7 in. thickness of the road, and after being a fortnight in a dry room and then immersed for eighteen hours in water, the absorption was found to be approximately 3 per cent.

The lengths of the various roads put in hand up to date totals just over 8 miles, and all the work, with the exception of steel work for bridges, has been carried out by direct labor. At the busiest times nearly 2,000 men have been employed and 400 tons of material handled per day at the various stations and depots adjacent to the works. During the course of the work four bridges have been constructed to carry the various roads over railways. All these bridges are 100 ft. wide between parapets, and three of them wide enough between abutments to span four lines of rail, one of them only being constructed to span two lines of rail. These bridges have been designed to carry a weight of 30 tons on a 6 ft. by 8 ft. 6 in. trolley, with an allowance of 50 per cent for impact.

Some lengths of these roads have been opened to traffic for over a year, and other concrete roads in Manchester have been under traffic for two years, and as far as can be seen from this short trial, the surfaces show little signs of wear.

**Over $400,000,000 Spent on English Roads.**—According to the British Ministry of Transport, £85,000,000 ($413,000,000) has been spent on the roads in the country during the last two years, six-sevenths of which is normal expenditure and only one-seventh concerned with unemployment. A much greater sum will be spent within the next two years in road improvement schemes, for important projects by county and other road authorities have been approved, whilst numerous others are being prepared.

Pile Foundations and Clay

Summary of Various Investigations in the United States and Great Britain.

By H. C. H. SHENTON.

From The Surveyor, London.

Considerable difference of opinion exists with regard to pile foundations. Various workers are giving attention to the physicial properties and bearing values of soils for foundations, notably the special committee of the American Society of Civil Engineers, who are dealing with the whole subject. The work, is, however, without limit owing to the infinite variety of conditions. When a pile is driven or is made to support a load there are many reasons which account for the results observed.

Experiments at Pennsylvania State College.—For instance, recent experiments made at the Pennsylvania State College showed that the distribution of pressure under loaded piles taken at various distances and depths formed what was called a bulb of pressure. The load was applied by means of a hydraulic jack, and the resisting pressure of the earth was measured. Tests were made on different soils with different pressures, and gave similar results. Thus at a depth of 6 in. below the surface the pressure was about 90 per cent of the maximum soil pressure, while at a depth of 59 ft. it was only 3 per cent. If an ordinary plant bulb were cut in half vertically, the various layers would represent graphically these earth pressures, the large outside layer being least in intensity. It is thought that this fact explains how a soil can take great pressures, the bulb merely spreading the load over such a great area that the unit pressure is reduced to a value which the soil can sustain without settlement. This naturally affects the spacing of piles, and shows that there can be no advantage in having the piles too close together.

It is extremely interesting to note that the bulb of pressure may explain the fact of the rebound which often occurs after the impact of the pile-driver, or after a load has been removed from the pile. The experiments show that when the load is released an elastic expansion of the bulb takes place, but in this expansion the bulb partly breaks down—that is to say, the earth is disturbed and the bulb is formed again at a lower level on reapplication of the load. An examination of the bulb of pressure also shows the closeness of the different intensities of pressure near its top, and it is also thought to show that in no sense has earth in this condition liquid properties, but that it is a true solid.

Ackermann's Experiments With Clay.—On the other hand we have Mr. Ackermann's experiments with clay, which tend to show that clay becomes fluid at a certain pressure. With regard to this matter, Dr. Herbert Chatley, in his paper upon Physical Properties of Clay Mud, read recently before the Society of Engineers, says: "Ackermann holds that fluidity pressures occur in clay under pile points during driving or when loaded, until sufficient frictional force is developed. This is not the case in the general mass of clay, so that the flow, if it does not occur upwards to the surface round the pile, must take place radially and displace water from the general mass. It has not been observed how far such transmitted effect goes, but approximate calculations indicate that drying of this kind extends through a radius several times that of the pile itself. Close piling must either raise the mud surface or very appreciably dry the material between the piles." Dr. Chatley's description seems to suggest that a bulb of dried material out of which the water has been pressed is created at the base of a pile, which appears to have some resemblance to the bulb of pressure mentioned in the Pennsylvania experiments.

Recoil of Piles.—With regard to the rebound of piles, the tests made in America by Mr. J. F. Greathead, of the Public Service Commission, showed very clearly that clay, sand, and also gravel have distinct elastic properties of great importance in pile foundation work. Experimental piles driven showed a very distinct rebound after the load had been removed. A pile sunk in sand containing 10 per cent of clay settled 7½ in. when a load of 40 tons was applied and then came to rest; after the load had been supported for three minutes it was removed and the pile jumped up nearly ½ in. A second pile settled 8 in. when loaded with 40 tons, sustained this load for three minutes and rose ½ in. when the load was removed. The load was then reapplied and the pile sank 1 in., rebounding slightly when the load was removed. The fact that the pile which had maintained a load of 40 tons for three minutes sank 1 in. when the same load was reapplied is instructive, but another experiment is still more instructive. In this a pile loaded with 80 tons settled 11 in., rebounding ½ in., settled 1 in. when the same load was reapplied, rebounded ¼ in., settled a further 1 in. on reapplication of the same load, rebounded ¼ in., settled a further ½ in., and rebounded ⅛ in., all with the same load of 80 tons. The bottom of this pile was on gravel. Another pile settled and rebounded five times under the application of 20 tons, settling 5 in. on the first application, and showing a final total settlement of 7½ in., the average rebound being a little under ½ in. It was clearly shown that the earth was elastic, and that after settlement and rebound the pile would generally sink further under the same load.

Following on these experiments the method of holding piles down until the permanent load could be applied so as to prevent rebound and consequent resettlement was adopted in actual practice. The loads on certain piers driven to support a building were maintained on each pile by means of hydraulic jacks, and the rebound was thus held down until the permanent weight of the building came on to the piers.

Tests With Pile Set Gauge.—The set and rebound of piles is obviously a matter deserving careful attention, and the autographic pile set gauge recently invented by Mr. Ackermann and described by him in a paper read before the Society of Engineers is important. This gauge gave accurate results in experimental work, but hitherto, no records have been published of the results of tests made on actual constructional work.

The following figures taken from actual working with the Ackermann autographic pile set gauge on "Simplex" steel pile tube 16 in. external diameter and 30 ft. long, driven by a 38½-cwt. drop hammer, falling about 5 ft. each blow, are of considerable interest. The test took place at Butler's wharf Shadwell, on June 6, 1922. The piling contractors were Messrs. J. and W. Stewart, whose chief engineer, Mr. Kruse, and their representative, Mr. Robertson, witnessed the tests:

The 24 blows at 3.06½ p. m. were to drive the tube to a smaller set, so as to test the instrument on a smaller set. The large amount of elastic recoil is remarkable.

RECORD SUPPLIED BY MR. ACKERMAN.

Time p. m.	Series No. of card.	No. of blows.	Actual set in 16ths in.	Set recorded by autographic curve 16th in	Elastic recoil of top of pile 16th inch.
2:59	(a)	1	13	13	9
3:02	(b)	1	13	13	7
3:04	(c)	1	14	14	6
3:06½	..	24	..	..	..
3:14	(d)	1	6	6	5
3:18	(e)	1	4	3½	7
3:23	(f)	1	4	3½	6
Totals	..	30	54	53	40

Total error for the 6 records—1/16th inch.
Mean error for the six consecutive records—1 in 54 = —1.85 per cent.

Pile-Driving Experiments of Whangpoo Conservancy Board.—The experiments carried out by the Whangpoo Conservancy Board in connection with the Shanghai Harbor Investigation were dealth with in two reports published in 1921. These were loading tests. The piles varied from 16 in. square and 59 ft. long to 4 in. square and 10 ft. long. Most were of timber and some were of concrete. £8,000 were spent upon this experimental work, and the results are of considerable importance. In a paper read before the Society of Engineers in 1919 Mr. Ackermann recorded certain experiments which he had made personally on a small scale. It is extremely interesting to note that certain facts were established, there being a complete agreement between the model experiments made in England by Mr. Ackermann and the full-scale experiments made at a great cost in China. It was shown that the resistance per unit of area of the pile decreases with the length of the pile. The Whangpoo experiments showed that the load and the sinking increase almost in proportion to a certain point, beyond which the sinking rapidly increases with the load, the adhesion between the clay and the pile being easily destroyed by rubbing the pile against the clay. The same fact was noted by Mr. Ackermann, who considered that the increased penetration with increased load was due chiefly to the pressure of fluidity having been reached, and possibly also to the pile having rubbed itself free in the upper portion that had penetrated. The Whangpoo report stated that the shape of a conic pile should for these reasons be better adapted to a clayey soil, while Mr. Ackermann's experiment also showed that for equal depths tapered piles support a larger load per unit volume of the pile than piles having parallel sides. Mr. Ackermann's well known claim that clay has a definite pressure of fluidity and that when this pressure is reached and maintained the clay yields indefinitely as a dense viscous fluid, is to be compared with the statement in the Whangpoo report to the effect that an elastic limit exists in the clay, and that the sinking of a pile increases in a faster ratio until stress is reached, where the strength of the mud is exceeded and the pile continues to sink under a constant load, which sinking does not cease until the area of the pile in contact with the clay becomes large enough to hold up the pile by friction. Mr. Ackermann's experiments showed the same thing.

Piles Sink Under Load.—Lieut-Col. H. R. Lordly has quoted the case where some piles driven in blue clay to a load-bearing resistance over night had disappeared next morning under this load. It seems, therefore, to be fairly well established that piles driven in clay may be supported by friction, that conical piles have in this respect greater supporting power than piles with parallel sides, also that the resistance offered by the clay at the base has a value which ceases to exist when the loading is increased in intensity beyond a certain degree, because the clay becomes fluid in the same way that lead will become fluid under a certain pressure, a fact of which advantage has been taken recently in making certain flexible pipe joints. It is interesting to note that Mr. Crosthwaite, while he does not entirely agree with Mr. Ackermann's theory of the pressure of fluidity, obtains similar results with china clay when tested with loaded discs.

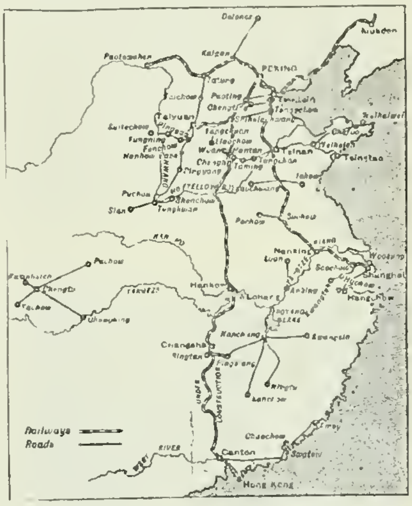
Expansion of Clay.—The expansion and contraction of clay are matters deserving of close attention. Prof. Giesecke of the University of Texas, has made certain experiments recently. He found that the moisture content in a 6 ft. layer of clay under a building had produced a vertical expansion of about 4 in. which had caused considerable damage. An experiment was therefore made by filling a 2-in. brass cube mould with compacted pulverized clay. This clay was allowed to absorb water while the mould rested on a brass plate. The clay expanded vertically a little more than a ¼ in. above the mould, and the mould was lifted .049 in. off the brass plate. The contraction of clay in dry weather and possibly the expansion of clay in wet weather are matters which give us much trouble in London. Mr. Wentworth Sheilds has described clay as a substance which lets down the finest bridges and stoutest retaining walls, a substance which can never be depended upon, and which behaves in a most erratic and unexpected fashion.

Hydro-Electric Developments in Italy.—According to the Minister of Italian Public Works, the hydraulic power now being utilized in Italy amounts to 1,191,979 H.P. When the work now in hand or projected is finished, Italy will have at her disposal 1,986,333 H.P.

Road Building in China

From The Engineer, London.

To those who lived in China 10 or 20 years ago the idea of writing about roads in that land will seem almost ridiculous, for there was then nothing worthy of the name throughout the country, while there seemed little prospect of substantial highways being built for years to come. Within comparatively recent times, however, especially since the great famine, some important roadmaking schemes have been formulated, some of them put in hand, and regular services of motor cars have been organized to provide communication between towns and cities. The wide field which this policy covers is indicated in the sketch map. On it there are shown most of the principal highways projected, in course of construction or finished, while the main railways and the three big rivers are included.



Map Showing China's Projected Roads.

A Chance for Labor Saving Machinery.—It is of course, to the construction of more railways that European engineers look as a means of developing the resources of China and finding an outlet for their manufactures. Unfortunately, railway building is practically at a standstill just now, and is not likely to be proceeded with until the political situation of the country becomes more stable. In the interval, however, roadmaking is progressing fairly rapidly, largely on account of the opportunities which it offers of giving employment to people left destitute by the famine and who are more or less maintained by foreign philanthropy. Many of these roads will undoubtedly form important links in the means of communication and as feeders for the railways and rivers; and while, under the present regime, one of the chief considerations of the promoters is to employ as much labor as possible, it seems probable that the movement may ultimately lead to the adoption of modern mechanical appliances for assisting labor.

The hopes of the promoters are supported by the experience of reformers in other somewhat similar directions. Thus on the West River some important reclamation schemes have been undertaken and, although there was some difficulty at first in getting the funds necessary to carry them out, the works have resulted in such an increase of local prosperity that the policy is being extended rapidly and the landowners are becoming quite willing to finance the business. But reclamation work is a class of engineering with which the Chinese have been familiar for centuries, while roadmaking, in the European sense, has been entirely neglected. That is to say, of course, outside the settlements and concessions, where there are many first-class roads. In the native cities there are narrow streets, of which the pavement comprises great stones, as shown in one of our pictures, that also serve as the cover of the drains beneath and which have to be lifted periodically for clearing out the sediment; but outside the cities there are the merest tracks indicating the route from one place to another. Along these tracks the traffic finds its way as best it can in the circumstances.

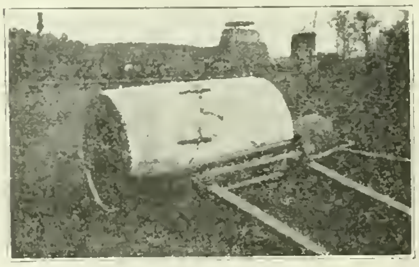
Primitive Methods of Conveyance.—In the North the two-wheeled cart is the principal conveyance, and to it is hitched any animal, or animals, that may be available. The "going" is so heavy, either on account of the mud or the dust, that anything with four legs is impressed for drawing the carts, and it is no uncommon sight to see a mixture of, for instance, an ox, a camel, a few ponies and donkeys, and even the womenfolk tugging at a single cart. And, in view of the fact that no attempt is made to prepare the surface of the earth for the traffic, it is really surprising that the carts are kept going at all. One of the illustrations gives some idea of the obstructions which have to be surmounted in the more hilly districts. The cart was actually in motion, going over the boulder shown in the picture, when the photograph was taken. Stones, such as these, strew the tracks, and no systematic effort is made to clear them away.

Peking Cart on a Rough Road.

The natural condition in the northern part of China, in Shansi and the other provinces bordering on the great bend of the Yellow River, are very arduous for the road engineers, and account to a large extent for the primitive state of affairs. Away from the hills the country comprises great stretches of loess, a soft neutral-tinted earth, which, although it will stand with a perpendicular face of considerable height when it is dry, disintegrates very rapidly when wet. Such material as this cannot be classed as good for roadmaking, but there is little else to be found for stretches of hundreds of miles, and road metal must be brought from distant quarries.

Added to the difficulty of finding suitable materials, the road engineer is faced with the problem of combatting floods that annually spread over miles of the countryside, and also with providing a surface that will wthstand the punishing effect of the native traffic. Besides the Peking cart, with its menagerie of draught animals, there is the wheelbarrow of the North. This barrow has a wheel about a yard in diameter, shod with an iron tire not more than 1½ in. wide. The load is balanced on either side of this wheel and may amount to some 5 cwt., or, say, half-a-dozen passengers. The handles are spaced very widely apart and a band fixed to the handles passes over the shoulders of the coolie to help him in steadying the load. Sometimes another coolie pulls on a rope in front, as shown in one of our pictures. Large numbers of these barrows are employed, and they always follow closely in one another's tracks. The result is that the narrow tires cut deep grooves in the road. Even the granite-paved roads of the settlements cannot stand up to the wear and tear, and a narrow and dangerously deep groove is worn in the stones near the gutter. The seriousness of the ruts which are formed in the earth roads, by the combined effects of traffic and weather, may be judged from the fact that for a motor car to negotiate them the back wheels have to be allowed to slide gently into the depression and the low gear must then be used for climbing out again on the other side.

In the more southern part of the country this trouble with wheel ruts is not encountered, for the simple reason that there is no wheeled traffic. The tracks will not bear a wheeled vehicle, while there are very few, if any, draught animals. Merchandise is carried on poles by coolies and passengers are conveyed in sedan chairs. The coolies bear loads of about 100 lb., or, if they are carrying on their own account, often twice as much, and pick the best way they can across the country. The constant traffic—and it is very heavy—beats out a hard path in the soft soil; but unless it is above flood level the track is obilterated annually and must be trampled out again when the mud dries.



Native Stone Rollers.

It will be readily appreciated, in view of the above notes, that the problem of providing China with good roads is not only a difficult one, but also one of great magnitude. Already quite a number of so-called roads have been made in various parts of the country, but it is very difficult to get authentic information concerning the schemes taken as a whole, and there is no doubt that many of the roads which are reported to have been completed have only rolled earth surfaces. The metalling of these roads is being postponed until funds are more easily obtainable.

Typical Native Rollers.—We give an illustration of some typical native rollers used in roadmaking. Some of these rollers are solid cylinders of limestone, 3 ft. or 4 ft. in diameter by about 5 ft. long, and are drawn by gangs of from 20 to 40 coolies according to their weight.

In the extreme south there is one instance where more modern methods of road building have been adopted. In the native city of Canton some fine boulevards have been constructed largely under American supervision. The city walls were pulled down to make room for the new roads, and it is noteworthy that native contractors competed eagerly for the work on condition that they might keep what they found. It has always been believed that considerable treasure had been buried in the wall, and it is said that several contractors made fortunes by their finds.

The Decarburization of Ferro-Chromium By Hydrogen

There has been developed recently in England a "rustless iron." This material is iron to which a certain proportion of chromium has been added. A similar alloy called "stainless steel" has for some time been familiar to metallurgists. Stainless steel differs from rustless iron chiefly in that it contains small amounts of carbon. In order to product rustless iron, an iron-chromium alloy free from carbon, it is necessary that carbon-free iron and chromium be available. The usual forms of chromium, commercial grades of ferro-chromium, contain comparatively large amounts of carbon. The discovery of rustless iron has thus made it very important to be able to treat ferro-chromium by some process which will remove the carbon. Among the methods proposed is that of heating ferro-chromium in contact with hydrogen. Through experiments conducted by the U. S. Bureau of Standards, it has been found that ferro-chromium heated in hydrogen loses carbon slowly at temperatures below the melting point of the alloy. When hydrogen is bubbled through molten ferro-chromium, the loss in carbon is very rapid. It may be possible to prepare low-carbon ferro-chromium by blowing hydrogen gas through molten ferro-chromium in a converter of the type used in the manufacture of Bessemer steel. This work is described in Scientific Paper No. 448, available from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5ct. per copy.

A $4,000,000 Short Span Bridge in France.—What will, it is declared, be the most costly bridge for its size in the world will be the one to be constructed to take the place of that portion of the Batignolles tunnel which passed under the Boulevard des Batignolles, outside the St. Lazare Station in Paris. The demolition of the tunnel stops at the boulevard because at that point it passes under a complicated system of mains, as well as under the Metropolitan Railway, which have all to be carried over the new bridge. Its general design is a girder bridge with a tunnel for the Metropolitan in the center and a series of tunnels on each side for the water, gas, compressed air, electric and other mains. The contract for the work has just been given out, and the work is expected to be completed in two years. The cost of 20 million francs will be borne by the State Railways. The high cost of this short bridge, which will merely cross the railway, is due to the preliminary work of displacing the mains and demolishing what is left of the Batignolles tunnel.—The Engineer, London.

Roads and Streets Issue

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(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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Traffic Restriction and Segregation

Efficiency in street traffic accommodation is to be sought in two ways—the provision of streets and roadways adapted to the requirements of each case, and the adjustment of traffic to make the best use of admittedly inadequate highways when physical or economic conditions prevent the improvements necessary to ideal traffic conditions.

The former alternative can be had regrettably seldom either by the location of an important street in virgin territory, or by the widening of old or the cutting through of new streets in settled districts. Of course "permanent improvements" to provide for traffic will grow in number, especially as the use of motor vehicles attains to something nearer standard or mature proportions than it yet has, and thus enables us to predict future requirements with increased accuracy; but there will remain a vast number of streets where the depletion of traffic to operation in existing thoroughfares will afford the most economic solution of the problems of circulation and distribution. Such adaptation can be had only through regulation—often regulation as drastic as the limitation of travel on certain streets to one direction only, or the complete exclusion of some classes of traffic from the street either during certain hours or continuously.

Another reason for the limitation of streets to specific classes of vehicles occurs in the case of residence districts, where a large industrial or commercial traffic becomes objectionable. While these cases are usually of less importance than those involving congestion in downtown districts, they are by no means insignificant or without economic aspect; for the householder in a district intended for residential use, has a right to protection in his enjoyment of such use, and property in such districts suffers an actual depreciation in value when commercial vehicles invade the district in numbers.

Returning to conditions in the business districts, we must admit that the police handling of traffic, while good in some cities, is grossly inefficient in others, whether by reason of poor traffic rules, poor enforcement of rules or both. It will take a deal more careful study and a deal more heed to the results of scientific studies and solutions to put most of our streets into anything like the measure of useful service that they should have.

The one-way street is already well known and is destined to be known better. Its inconvenience, we believe, is more imaginary than real, or at the very least is far more than offset by the advantages. The hurried individual who is forced to travel three sides of a block to reach the fourth side is for the moment going to feel somewhat hostile to the one-way street; but the same person in an equal hurry to make a landing a long way down on the left bank of the same street will have a vastly different feeling. However, the important point for consideration is not that of individual feelings but the fact that under certain conditions the total time saved by the one-way street to vehicles and their occupants far exceeds the time lost.

In view of the start that the one-way street has made in popular favor, it is strange that the lesser restriction involved in abolishing the left-hand turn in crowded districts is so little known. In the case of a street carrying two streams of traffic in each direction a car turning to the left from an outside stream cuts and delays the other three lines, and also adds greatly to the chances of accident. Again an individual will sometimes have to take a three blocks extra trip, but the gain to the motoring public as a whole will be great. Furthermore, in both this case and that of the one-way street the experienced driver will, by proper routing, usually avoid these extra distances.

The segregation of traffic into classes—particularly as to speed—holds possibilities, although as yet not enough experimenting has been done in this field to show just what may be expected from it. Where streets are sufficiently wide, movement may be facilitated by dividing traffic into lines or lanes of heavy and light or slow and fast vehicles respectively. Where there is not sufficient width for this, there remains the possibility of assigning separate streets for each use, or what is much the same, excluding slow traffic from certain streets.

The problem of getting maximum service from our streets has received some very able attention, but it is in need of more. The most difficult part of the problem perhaps is the securing of suitable action by local legislative and administrative bodies. The field of effort is an attractive one; the necessities of the case are great; and it is to be both desired and expected that much more engineering talent will be drawn into it. With this talent there must be sufficient force to arouse public interest to the point of putting over the programs when they have been worked out.

The Alleged Mystery of Gravitation

By HALBERT P. GILLETTE, EDITOR

Prof. T. J. J. See, government astronomer at Mare Island, has announced that the cause of gravitation is etherial waves of much greater length than those of light, but having a velocity equal to that of light. Several astronomers and physicists who have been interviewed on this hypothesis have pointed out that gravitation acts instantaneously, whereas light does not. Charles Lane Poor, professor of celestial mechanics at Columbia University, is quoted as saying:

> "He (Laplace) showed that if gravitation be propagated through space with a speed as slow as even a million times that of light, the motions of the earth and moon would be measurably different from what they are. If Laplace was correct, you can readily imagine what enormous changes would occur if the speed were only that of light.
>
> "To prove his statement, Professor See would have to show either that all observations for the last thousand years are wrong, that the earth and moon are not what they seem, and have not been where they have always been seen, or else prove that the mathematics of Laplace, Leverrier, Newton and a whole line of eminent astronomers are faulty."

Commenting editorially, the New York Tribune says:

> "But what is this invisible force that operates across these vast spaces? By what means does it pass from sun to planet, from earth to a leaping human—and vice versa? Science has thus far not reached the beginning of an hypothesis. The hypothesis of an invisible ether has proved of value in the investigation of light. Not even this much of a trial theory has been suggested for the force of gravity. So far from clearing up the mystery of the solar system the discovery of gravity but added to the marvels of its order and rhythm. We can now calculate its force—a wonderful achievement Their source and character are still completely hidden."

The editor of the Tribune errs in saying that science has thus far not even reached the beginning of an hypothesis as to the cause of gravitation. About a century ago an Italian scientist proposed an hypothesis that certainly goes a long way toward explaining gravitation. He assumed that every atom of matter is bombarded by etherial corpuscles, and that some of these corpuscles pass through the interstitial spaces of the atom while some of them fail to penetrate the atom. The result of such an action would be that for any two atoms there would be a mutual "shading" of the one by the other. That is, there would be fewer corpuscular impacts on the sides of the atoms that face one another than on the opposite sides. This unbalanced pressure of the ether would tend to drive two atoms toward one another. It follows as a necessary consequence of this theory that the gravitational attraction between any two atoms would vary inversely as the square of the distance between them and directly as the product of their masses, which is the basic Newtonian law of gravitation.

According to this hypothesis, gravitation is not a "pull" of one body by another, but a "push" of two bodies toward one another by an unbalanced bombardment of etherial particles. To illustrate, suppose a vertical cylinder containing air had a piston that is supported by the compressed air. The bombardment of the molecules of air on the bottom of the piston tends to lift the piston; but the unbalanced bombardment of the etherial particles (which is gravitation) tends to force the piston down. When these two pressures equal one another there is no relative motion of the piston and it remains at the same place in the cylinder.

The main objection to this explanation of gravitation was that the etherial bombardment would raise the temperature of all bodies indefinitely. But an answer to this objection is that the bombardment of compressed air molecules in a closed cylinder does not raise the temperature of the cylinder. Why then should it be contended that etherial bombardment must raise the temperature of a body? Moreover, the ultimate nature of heat itself is not well enough understood to warrant the assumption that the impact of an etherial particle with an atomic particle would cause heat.

When an hypothesis explains facts otherwise inexplanable, it should not be cast aside even when it appears to be inconsistent with other facts; for further investigation may clear up the paradox. Thus when Copernicus announced the hypothesis that the sun and not the earth is the center of "our universe," it was objected that if so, Venus should show phases such as our moon shows, whereas Venus seemed always to be "full" and never in crescent. Not till Galileo invented a telescope was it discovered that Venus does have her phases, and that the previously limited knowledge of the laws of light had made it seem that the Copernican theory was wrong when in fact it was right. Many similar instances occur in the history of science, indicating the falsity of the reasoning that leads to summary rejection of a theory either because it fails to explain all collateral facts or even because it is in seeming conflict with some facts.

The etherial wave theory of light struck "snag" after "snag," and at times seemed doomed to final abandonment, but each time a little more investigation served to establish its fundamental verity. The latest "snag" is the Einstein theory of relativity, which seemingly makes the ether an unnecessary hypothesis. In view of the repeated victories of the etherial wave theory of light in the face of much greater objections than now confront it, does it not seem probable that it will triumph again?

The ether has been called "an impossible thing," because it is entirely without inertia, tennous beyond every known gas, and yet more rigid than any solid. But when the cause of inertia is understood, it may be found that only atoms possess it, and that the atoms themselves are groups of etherial particles which taken separately, have neither inertia nor heat, but which, taken as a system called an atom, have both inertia and heat.

To the writer it seems far preferable to accept the unbalanced corpuscular bombardment hypothesis of gravitation than to have no explanation whatsoever of this alleged mystery. Not only does it explain the basic Newtonian law of gravitation, but it meets the demand for a conceivable mechanism that acts instantaneously across space so as to cause every atom to "attract" every other atom.

Road Development for National Defense

Road development needed for national defense as planned by the General Staff of the Army has recently been indicated to the Department of Agriculture by the Secretary of War and the information has been placed in the hands of the engineers of the Bureau of Public Roads who are at the present time getting into final shape the plan for the system of Federal-aid highways. This system will consist of approximately 180,000 miles of road, so laid out as to serve all parts of the country and will be built by the States in conjunction with Federal aid.

The General Staff has been investigating the subject since 1919, the Bureau of Public Roads collaborating. Briefly summarized, the report made is as follows: There are certain vital areas along the boundaries of the United States against which any invasion will probably be directed. These areas have been outlined by the General Staff. For military purposes they should be connected with the centers of production and storage and industrial centers. The roads will then become strategic lines of supply and will usually conform with roads located for other purposes. Transcontinental routes are of no particular value for military purposes.

The plan submitted by the War Department shows important centers that should be connected but does not give detailed routes. Engineers of the bureau state that these points can be connected by roads without any serious dislocation of the plan of development for other purposes and that in general the military need for roads conforms with surprising closeness to the commercial and economic needs. It is thought that the plan submitted can be embodied in the Federal-aid highway system and thus make the system an important factor in our plan of national defense.

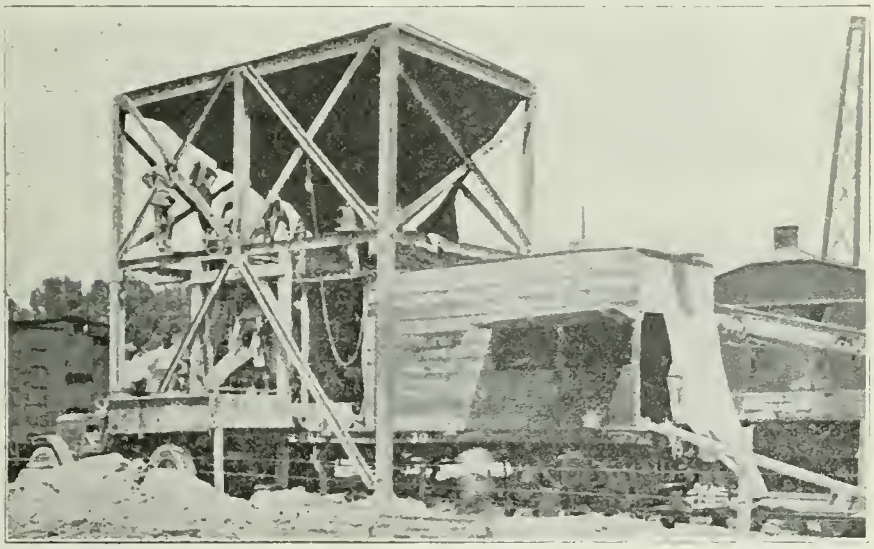
Roads of a purely military nature such as those leading to coast fortifications have not been included in the plan submitted and will be handled by the War Department as heretofore.

Portable Road Building Outfit

Important Units of Equipment Mounted on Railroad Flat Cars

A concrete road building plant mounted on railroad flat cars gave good service the past season in constructing highways in Woodbury county, Iowa. We are indebted to the service annual bulletin of the Iowa State Highway Commission for the following information regarding this outfit:

When C. F. Lytle of Sioux City, "capitalist," found that as a result of Woodbury county lettings he had in hand a 14-mile contract for concrete pavement with two or three settings of an outfit necessary and with other jobs in prospect of rather short mileage, he determined to organize an outfit and design a plant and equipment so that as little time as possible would be actually lost in the necessary moving. A central proportioning and mixing plant was selected as best adapted for the work on hand and in prospect.



The Mixing Plant. The Power Plant Is Housed In the Wooden Cabin.

The Mixing Plant.—A railroad flat car of ordinary type was one of the first purchases. On one end of this was mounted a Lakewood Mixer of 56 cu. ft. capacity per batch. On the other end the Wisconsin Model M. gas engine was mounted with a belted drive connecting to the mixer. The engine was housed in with a wooden cabin for protection from the elements. Fabricated steel was used to build a frame work about the mixer to support the necessary hoppers above for sand and gravel and with heavy bolted removable supports to rest upon the ground and give stability to the outfit. Two long canvas belt carriers extending directly along the car side at the back of the mixer provide two separate elevators for the cement which is dumped from the sacks into the carrier hoppers from the cement supply cars at either end of the mixer car. Two cement carriers are necessary to keep an unbroken supply of material. When working at full capacity, one carrier with one crew emptying cement sacks into the hopper at the bottom cannot supply the mixer. Fourteen full sacks of cement are required for each batch. The two carriers also make unnecessary a complete shut down of the mixer equipment while one cement car, after being emptied, is run out and the new one brought in.

A locomotive crane unloads the sand and gravel from the supply cars into the reserve stock pile. It keeps the hoppers at the top of the proportioning bins filled and ready for dumping as each new charge is required.

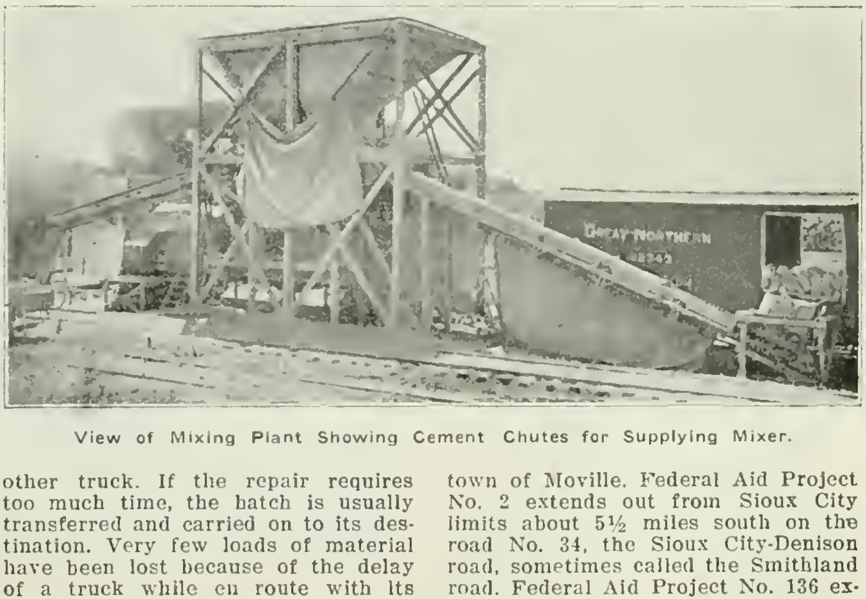
How The Trucks Are Cared for—Twenty Special Kissel Road Builder Trucks Were Used on This Job.—A fully equipped repair shop with competent foreman and several mechanics is maintained to keep the trucks and the balance of the equipment in the best condition at all times. When a truck has tire or any other trouble when out on the road the first truck passing him carries the word to the repair shop and a service truck, fully prepared, if possible, to meet the needs of the emergency at hand, makes the run with very little loss of time. If the repair can be made on the spot by the roadside in short order it is unnecessary usually to switch the load of wet batch concrete to another truck. If the repair requires too much time, the batch is usually transferred and carried on to its destination. Very few loads of material have been lost because of the delay of a truck while en route with its load. The trucks, even when loaded, travel at a high rate of speed and the wet concrete batch has been successfully transported a distance of eight miles without detriment. The entire round trip at the time the eight mile run was being made took approximately one hour. So carefully have the mechanical needs of the trucks and other equipment been looked after by the repair shop and its force of men that in four months' time practically no delay has been experienced on account of having to make repairs on equipment during working hours.

A Lakewood subgrader is used to shape up the grade and a finishing machine of the same make, shapes, tamps and gives the finishing touch to the concrete slab. This machine is followed by hand finishers who complete the work of surface finishing, build the sloping integral curb on steeper grades and the special design drainage intakes. These latter are built into the edge of the slab at the curb line.

Caring for its equipment does not absorb all the attention of the company. To keep the men satisfied and contented on the job has been one of the features which has led to the good construction record made by the company.

Housing and Feeding the Labor.—To house the kitchen and dining room, two box cars of the Palace horse car type were purchased. One was entirely rebuilt inside and equipped, at one end, with a complete camp kitchen outfit. This contains all supply bins, shelves and refrigerator. The balance of the car not needed for the kitchen was rebuilt as a small dining room. The second car was entirely equipped as one large dining room. It is possible to seat comfortably, in the two rooms, a total of 75 men at one time. Sleeping quarters for the men are provided in tents or frame buildings if the latter are available or the time on the job seems to warrant. A special cook shack and sleeping quarters are provided for all colored help on the job.

The Lytle construction for 1922 for Woodbury county covers approximately 14 miles of concrete pavement in three separate projects. Primary Road Project No. 187 covers a little over one mile on road No. 23 in the town of Moville. Federal Aid Project No. 2 extends out from Sioux City limits about 5½ miles south on the road No. 34, the Sioux City-Denison road, sometimes called the Smithland road. Federal Aid Project No. 136 extends south from Sergeants Bluff to



View of Mixing Plant Showing Cement Chutes for Supplying Mixer.

Salix on road No. 12 approximately 7 miles.

Thirteen days of work on the Sergeants Bluffs road netted in actual accomplishment, an average of 718 feet of concrete pavement laid, an average of 1,436 square yards of concrete slab 8 inches thick and 18 feet wide or 320 cubic yards of material actually placed on the road.

Fifteen days' work on the Smithland road netted an average of 620 feet of pavement slab laid, per day, 20 feet wide and 8 inches thick, an average of 1,376 square yards of road surface covered or 340 cubic yards of material placed.

Twenty-five days' work also on the Smithland road, but of 18 feet width pavement, averaged 850 lin ft.

U. S. Bureau of Public Roads' Traffic Tests at Arlington

Traffic has been started on the circular track of the Bureau of Public Roads of the United States Department of Agriculture, at the Arlington Experiment Station, in the experiment to determine the canse of waving in bituminous surfaces. The track is composed of 27 sections of asphaltic concrete of different mixtures.

Before starting, the traffic prfile measurements of the surface were taken with the autographic profile device especially devised for the purpose. Measurements were taken at frequent intervals and will be repeated from time to time as the tests progress in order to determine the rate of formation of inequalities in the surface.

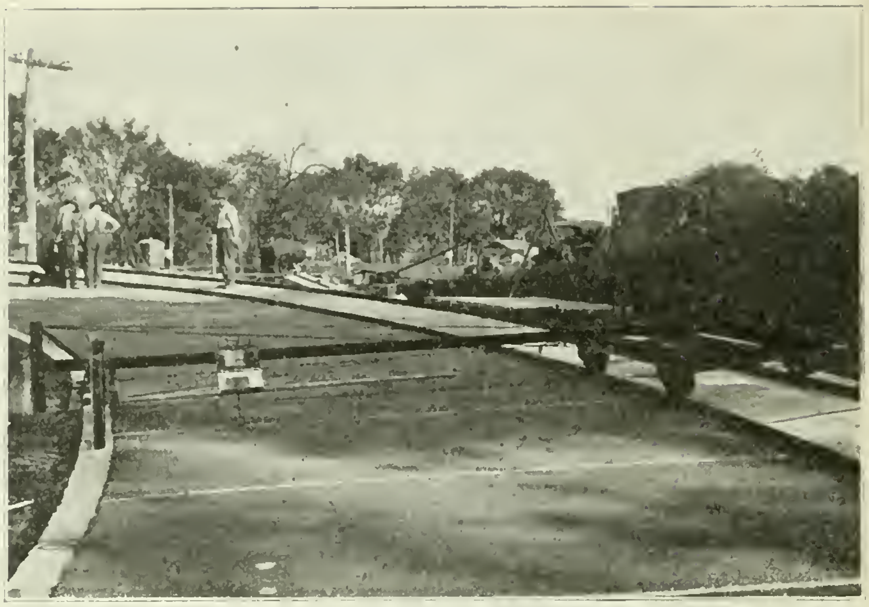
It is also planned to study the flow of the bituminous concrete under traffic. This will be done by noting the movement of brass plugs placed in the surface both in the upper and lower portions.

At present traffic is being confined to a path 2½ feet wider than the distance between outside edge of tires in order to obtain an accelerated test. This will also leave a space on the track for investigation under summer temperatures.

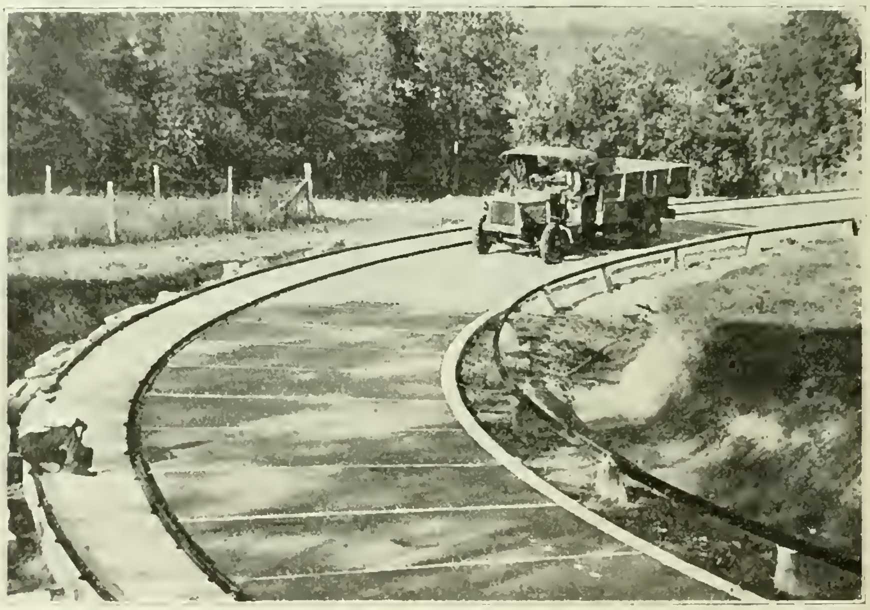
The wear test on the circular track consisting of 61 sections of concrete and located at the outside edge of the bituminous track has also been commenced. In this test concrete made of a great many different materials and mixes is being subjected to a traffic of two solid rubber-tired wheels loaded with 600 lb. per inch of width of tire or approximately that of a 5-ton truck and travelling at a speed of 20 miles per hour. The device used will be guided by wheels travelling on rails and is electrically driven, the power being transmitted to one of the wheels used to represent the traffic which will make this wheel act as the drive wheel of a truck.

On both the bituminous and the concrete wear test, traffic will run continually during working hours, but from the nature of the tests thousands of trips and a considerable period of time will be necessary before much data is secured.

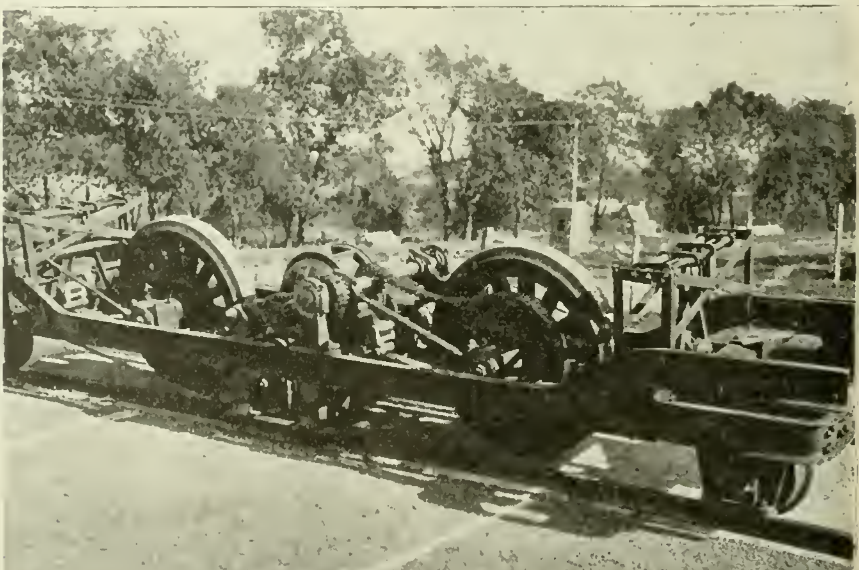
400 Per Cent Increase in Improved Roads in Wyoming.—Improved roads in Wyoming have increased from a total mileage of 1,724 in 1914 to 6,867 in 1921, according to the Bureau of Public Roads of the United States Department of Agriculture.



Appartus Used to Make an Initial Record of Irregularities of the Surface.



Circular Track to Determine Cause of Formation of Waves in Bituminous Surfaces with Traffic in Operation. The Concrete Track Is Shown at Outside.



Electrically Driven Device, Designed to Act as the Front and Rear Wheels of a Loaded Truck, Used in Concrete Wear Test.

Methods and Cost of Constructing New Brick Surface on Old Base

During the present season a 31-year-old brick pavement on the Beaver road at Sewickley, Pa., was taken up and a new brick surface laid on the old hand mixed natural cement base. The following details of this work are given by John C. Hiteshen, Borough Manager, in Dependable Highways:

The entire job of repaving was done by day labor by the Borough forces. The removing and hauling of the old brick was not charged against the job as it was anticipated the salvage value would pay for this work. A price was set of $2.50 per thousand for the brick on the street in case the purchaser would do the hauling, or $5.00 per thousand if they were delivered. The cost of this part of the work was $413.47 or $.08 per yard, and the Borough received $531.37 for those sold, making an actual profit of $117.90 in addition to approximately 40,000 whole brick that were hauled to the yard for gutters, etc. The bats were either given away or hauled to the dump, and all brick solo and salvaged were entirely whole.

The crown of the street was very irregular and some difficulty was experienced in securing a shapely job. Where uneven places were found in the foundation they were built up either with concrete or Tarvia cold patch. Granulated slag was used for bedding course at a cost of $2.50 per car plus freight.

Brick were hauled from the car, dumped on the street, and then stacked. Two large rope mats were used to dump on, and very little spalling or breaking of the brick was caused by this method. The small percentage chipped or broken were used in filling in the ends of courses, around manholes, etc. A small lawn roller was used to compact the cushion and a 5-ton tandem roller used to roll the brick.

A 300 gal. asphalt kettle was used to heat the asphalt and squeegee pots of 3 gal. capacity used to apply the material. It was found necessary to go over the street with these pots three times in order to properly fill the joints. A thin layer of sand was spread over the pavement after asphalting and allowed to remain about a week, although the street was opened to traffic immediately after the asphalt and sand were applied.

It will be noticed that the cost of truck and team is very low, but these are actual costs of each, figured on a basis of all costs of repairs, feed, parts, tires, etc., but of course do not include the cost of driver, which is figured in the labor costs.

The detailed cost of the improvement was as follows:

	Total.	Per sq. yd.
Hauling Slag for Cushion—		
229 hrs. labor, 30 ct. to 45 ct.	$ 85.60	
63 hrs. truck, 50 ct.	31 50	
30 hrs. team, 25 ct.	7.50	
Total	$ 124.60	$0.0243
Preparing Slug Cushion—		
12 hrs. foreman, 42.7 ct.	$ 5.12	
243 hrs. labor, 35 to 45 ct.	92 95	
Slag	44.02	
Total	$ 142.09	$0.0274
Hauling and Stacking Brick—		
34 hrs. foreman, 42.7 ct.	$ 14.52	
908 hrs. labor, 35 to 50 ct.	326.95	
74 hrs. truck, 50 ct.	37.00	
122.5 hrs. team, 25 ct.	30.62	
Total	$ 409.09	$0.0789
190.000 3-in. Vertical Fibre Block at $25 50 per M., less 3.862 not used	$4,746.52	$0.9160
Laying Brick and Rolling—		
48 hrs. foreman, 42.7 ct.	$ 20.50	
734 hrs. labor, 35 to 50 ct.	271.25	
4½ days roller	99.00	
Total	$ 390.75	$0.0754
Asphalting—		
Hauling asphalt	$ 9.45	
Heating and applying—		
46 hrs. foreman, 42.7 ct.	19.64	
461 hrs. labor, 35 to 45 ct.	166.85	
2 hrs. team, 25 ct.	.50	
83 drums or 5,000 gals. asphalt	473.66	
Asphalt kettle 6 days at $7.50	45.00	
Total	$ 715.10	$0.1380
Miscellaneous Work—		
97 hrs. labor, 35 to 50 ct.	$ 36.50	
7 hrs. truck, 50 ct.	3.50	
13 hrs. team, 25 ct.	3.25	
Sand covering, 474 bu. at 10 ct.	47.40	
Gloves, spikes, thermometers, wear and tear of tools, etc.	42.50	
Total	$ 133 15	$0.0250
Grand total	$6.661.30	$1.2850

Taking Up and Hauling Old Bricks (See note)—
(Not charged against job.)

	Total.	Per sq. yd
60 hrs. foreman, 42.7 ct.	$ 25.62	
979 hrs. labor, 35 to 50 ct.	350.10	
55 hrs. truck, 50 ct.	27.50	
41 hrs. team, 25 ct.	10.25	
Total	$ 413.47	$0.0800

Note—

Received for old brick	$531.37
Actual cost of work	413.47
Profit	$117.90

40.000 brick delivered to yard for Borough's own use.

Scoria-Surfaced Highways in Montana.

Several road projects in Wibaux and Fuller counties, Montana, surfaced by the State Highway Department, with a red, clinkerous rock, commonly called scoria, have proved an extreme success, according to the Montana Highway News, the official publication of the department. Some of the scoria-surfaced roads built under the supervision of the Montana department have now been in use over two years and, with the same degree of maintenance accorded gravel-surfaced roads, have given complete satisfaction and promise to have a length of life at least equal to that of a gravel surface.

Scoria (the name is misleading, as the material is not of volcanic origin and the name has been erroneously applied for want of a better one) is usually found at the top of the high bluffs which characterize the topography of a goodly portion of the southeastern part of the state. Much of it has no overburden whatever, and the work of getting the material to the road has been comparatively simple. The material is believed to have originated by the burning of coal beds under a layer of sand and clay, thus causing the latter to form into the clinker now found. The color of the scoria is usually red in varying degree, depending, presumably, on the proximity to the burning coal. The color is usually attributed to iron, but investigation in the testing laboratory of the highway department indicates that scoria does not contain as much iron as ordinary yellow clay nor as much as an ordinary red brick. The material is practically insoluble in water.

The method that has been employed in quarrying and placing the scoria surfacing has been generally as follows: The material is first blasted from the deposit and broken to such size that it can be handled by a fresno and loaded into trucks. It is then hauled to the road and dumped, after which it is crushed by a 10-ton roller to the desired size. It is necessary to scarify it frequently in the process of rolling that all of the oversize may be crushed. Once crushed it is handled very much the same as gravel, but binder to hold it together is unnecessary. When complete the road offers a smooth, red, easily drained surface that is readily susceptible to substantially the same maintenance operations that are given a gravel surface.

Scoria has been used on four projects placed under contract by the highway department, namely, Federal Aid Projects Nos. 1, 35 and 61, in Wibaux county and Project 86-B in Fallon county. The prices have been somewhat higher than for the average gravel surface, but in the case of the projects on which it has been used it has been cheaper than gravel would have been due to the scarcity of the latter. The contract price for this item has been 40 ct. and 44 ct. per square yard, respectively, on two projects and $2.60 and $3.30 per cubic yard, respectively, on the remaining two projects. These contracts were all let at a time when prices were high, i. e., in the fall of 1919 and 1920.

When scoria was first adopted for surfacing the southeastern Montana projects it was predicted by some that the material, once on the surface, would powder up under traffic and blow away, but this prophecy has not come to pass on any part of the scoria-surfaced roads. Scoria has, on the contrary, withstood a very severe test of drouth and flood and exceedingly heavy travel, and every indication is that its wearing qualities are the equal of gravel

Motor Vehicle Production in October

Figures received by the Department of Commerce through the Bureau of the Census show a marked increase in the production of both passenger automobiles and trucks in October, compared with September. The total production of passenger cars in October was 217,098, compared with 187,128 in September, while truck production in October amounted to 21,416, as against only 18,656 in September. In October, 1921, production totaled only 134,734 passenger cars and 12,313 trucks.

The low figures for September this year were partly, although not entirely, accounted for by the closing of the Ford factories for a part of the month.

The following table gives the total production for each of the last four months, with corresponding figures for the same months of last year. With a few exceptions, the reports each month are from identical firms and include approximately 90 passenger-car and 80 truck manufacturers. October figures are subject to slight revision when all reports have been received.

AUTOMOBILE AND TRUCK PRODUCTION.
(Number of Machines.)

	Passenger car.		Trucks.	
	1922	1921.	1922.	1921.
July	224.057	165,574	21.357	10.766
August	249.225	167,705	24.200	13,080
September	•187,128	144,669	•18,656	13.648
October	217,098	134,734	21,416	12,813

•Revised.

Highway Engineering and Highway Transport

Development of the Fields and Their Need for Trained Men Discussed in Address Oct. 26 at Conference on Education for Highway Engineering and Highway Transport

By THOS. H. MACDONALD,
Chief, U. S. Bureau of Public Roads.

In May, 1920, before the first conference of Highway Engineering and Highway Transport Education, it was my privilege to present a paper on a very similar subject. About the same groups made up that conference that are again represented here. The essential difference, then, is the fact that we now have to guide us three years' experience in the development of a remarkable highway program, a program of highway improvement much beyond the conception of our most advanced ideas of only a few years ago. Out of this experience there are certain tendencies crystallizing which indicate clearly and most emphatically responsibilities that must rest upon all those who are and who should be concerned with the business of education.

Industrial Activity and Engineers in Public Service Field.—At the time of the first conference, this country had been passing through a time of intense industrial activity. We are now emerging slowly from a period of the greatest contrast, a period marked by industrial depression, liquidation, and deflation. From the record as it was stated then and out of these more recent experiences, materialize the principles of a major character if measured by their effect upon the highway development of this country, and major, too, if measured by the difficulty of overcoming them effectively. In outline these principles may be stated.

1. During periods of industrial activity industry takes annually a large draft of technically trained men. This is true whether applied to the young men upon whose diploma the ink is scarcely dry, or to the trained, efficient engineer of many years' experience.
2. The inducements of higher compensation, sure advancement and continuity of services are offered by industry to the individual of outstanding personality and technical preparation far in advance of the offers made by the public service.
3. During the periods of industrial depression there is a drift of engineers to the public service, but, generally speaking, not of the best qualified or experienced engineers.

Elaborating the point briefly, when the depression seized upon industry, large and small, and there came a general curtailment or shutting down of activities, many engineers sought the public service field, reluctantly and generally with greatly decreased compensation. Now that, despite major handicaps, a revival and expansion of industrial and commercial activity is again ahead, we can expect the repetition of our very recent experience of having the most available and best qualified engineers attracted and deflected to other fields. It will not be very long before this cycle is completed. These principles, which are in themselves an indictment, are the prologue. If this conference is to accomplish something big and if it is to assist, in the months and years immediately ahead, in the achievement of definite progress, it must concern itself with educational measures and policies that are broader in their application than the technical curricula of our educational institutions. It must do its part in helping to awaken and develop a real public conscience toward its own public service, and it must awaken the public's intelligence to a real appreciation of the magnitude and significance of the developing highway transportation.

Significance of Recent Highway Legislation.—First, consider the significance of recent highway legislation. The Federal Highway Act of November, 1921, gave us for the first time in the history of the United States, a plan for the development of a comprehensive system of highways serving the nation by perfecting a network into every part of every state. It contemplates the service of highways for interstate and transcontinental traffic, but none the less it provides for local traffic. It brings this major system of highways so close to the communities that a properly developed system of local roads will reach all those who are not served directly. But the direct service which will be provided by the major system itself will reach a very large percentage of our total population and carry a very large amount of the total highway traffic.

Preliminary estimates show that there will be included in the major system, which we may call the Federal highway system, approximately 180,000 miles, and even considering the improvements which have been made, it will require 10 to 15 years, perhaps longer, to complete that system. Last year we added about 10,000 miles of completed highways to this system. This year the record will be smaller, but there are included in these yearly totals a large mileage which must yet be surfaced or improved with a higher type of surfacing before the system can possibly be considered completed.

Principles of Federal Highway Act.—The Federal Highway Act establishes as conditions precedent to the continued participation of the states in the allotment of Federal aid, these principles:

1. That each state should maintain a highway department properly organized and equipped to supervise and administer the construction of new highways, and to maintain those already built.
2. That each state must provide state funds to meet the Federal aid funds, and not be dependent upon the various subdivisions such as counties, to supply the state's quota, and
3. That, probably most important of all, each state must provide sufficient funds to maintain the roads which are built and lift the responsibility from the shoulders of the local communities. A majority of the states have already incorporated in their state legislation these principles, and it was the result of the successful working of these principles in some states over a considerable period of time that led the framers of this act to require their universal adoption.

The states which must change their constitutions or their laws in order to comply with these requirements are already taking the necessary steps, and it is only a question of a very short time until they are made a part of the laws of all of the states. Note that this development in legislation accepts and provides for a plan of administration and supervision universal in its application, that can be satisfied only by an engineering organization.

This conference can evaluate the degree of accomplishment for the public benefit that lies between the results that will be secured by an adequate engineering organization, and the disappointments that will result from the failures of an inadequate organization. Can the general public be awakened as keenly to this difference?

The Field for the Highway Engineer.—Second, the field for the highway engineer is not so limited as might first be thought. It is not sufficient that there shall be competent engineers in the public service alone. There must be equally competent and well qualified men in the field of the producers and the allied activities. This field is partially covered by the following:

1. Engineering organizations such as county, municipal, state and Federal highway departments.
2. Contractors engaged in highway construction.
3. Producers or manufacturers of highway material.
4. Consulting and private engineers.
5. Commercial laboratories and inspection service.
6. Industrial educational associations.
7. Engineering and educational institutions.
8. The technical press.
9. Traffic engineers.

This latter is a new and at this time almost undeveloped field, but in the future it promises to absorb many men who will be engaged in a most valuable service.

Growth of Motor Traffic and Highway Improvement.—This list is not complete; there are many allied lines having relation to the general field of highway development.

Third, our production of serviceable highways is not keeping pace with the demand.

Because their use, their practicability and their continuing service are dependent upon improved highways, the growth and the use of the motor vehicle is the best index to the need for, and the probable future increase in the mileage of modern highways. During the little more than a decade since 1910 the number of motor vehicles in service on our public highways has increased more than 2,000 per cent. Permit me to repeat the figures which I have used before, which indicate the lag in the development of highways of modern type over the development in the use of the motor vehicle.

1. During the period 1910 to 1921 the potential number of motor vehicles demanding highway service increased approximately 2,000 per cent. Our actual expenditures for construction and maintenance of highways increased about 400 per cent.

2. During the period 1910 to 1918 motor vehicles increased more than 1,100 per cent, highway expenditures about 120 per cent.

3. During the period 1918 to 1921 motor vehicles increased about 900 per cent of the number registered in 1910 and highway expenditures about 400 per cent on the same basis.

It is not asserted that these figures are directly comparable, but it cannot be disputed that they are indicative.

Fourth, consider briefly the matter of highway funds. The total estimated expenditures for highways by all agencies and from all sources during the year 1921 amounted to more than $700,000,000. The figures for this year will probably fall somewhat below the figures for last year.

Funds Available for Engineering Services.—On the basis of the more conservative estimate of actual expenditures, and without attempting to fix closely the proper percentage of cost for engineering services, there should be invested annually, at the present rate, for the engineering and administrative control alone, from 30 to 60 million dollars. Considering that easily from 40 to 60 per cent, depending upon the type of work, will be used for labor, there will be available annually from 250 to 400 millions of dollars. These funds are available for the employment of skilled and technically trained men in the contractors' organization as well as for the employment of common labor.

It is hardly necessary to continue to tell of the large sums available, which may legitimately be used for the employment of highway engineers.

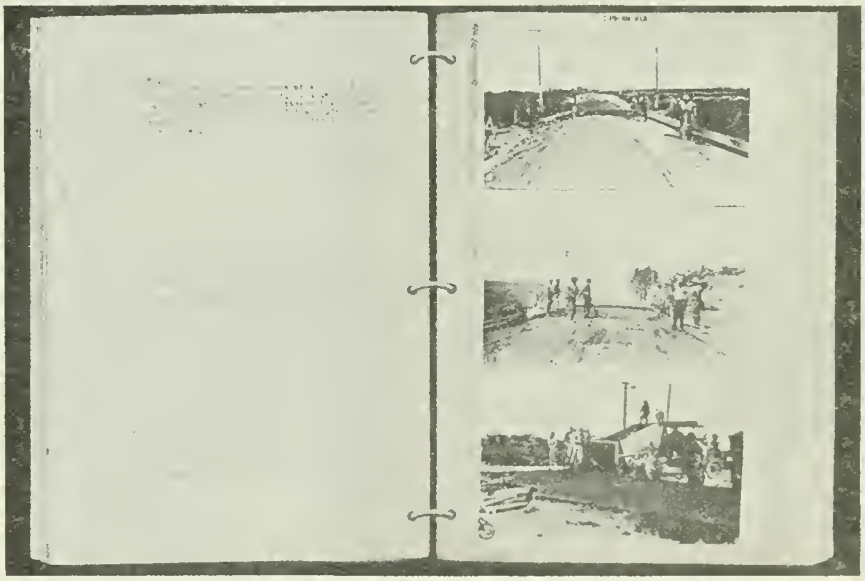
In summary, we find that the tendency of highway legislation is most favorable to the man who will consider the highway field as his future work. There are opportunities in more than a dozen of major fields directly connected with highway work. The rate of highway improvement has not kept pace with the demand which, together with the program now definitely recognized, make certain a long period of major activity.

The legitimate percentages of the total available funds which should be used for engineering and supervision are sufficient to insure employment to many men who are properly qualified and technically trained. As a commentary these facts do not, at least to me, indicate that the educational institutions should feel called upon to specialize in the teaching of highway engineering. For the graduate who would enter the highway engineering field I would personally prefer that he have a sound general course in mathematics, English, economics and kindred general subjects, rather than a number of specialized subjects. But, on the other hand, the graduate who is to enter the highway field should not be trained for some other engineering field. Referring back to the principles which were developed in the opening paragraph, there is here potentially a big, attractive field for the best trained men and the extent to which these men can be brought into this field and retained will be the measure of the economy and efficiency of the expenditure of the tremendous public funds which are inevitably to go into the building and the maintenance of our public highway system.

Bigger by far than any other problem before this conference is first the problem of awakening the public to the need for and the support of the highway administrative and engineering organizations engaged in this work, and second, that of educating the public to a proper use of the highways from a traffic standpoint.

Photographic Records as Aid to Road Construction and Maintenance.

A unique and thoroughly efficient photographic record system, adopted by the State Highway Department of Idaho is described by A. S. MacDougall, Assistant Engineer, Idaho State Bureau of Highways, in the December Highway Magazine. The article follows:



Typical Double-Page Spread of One of the Photographic Record Books.

Believing that the camera has a better memory than either contractor or engineer, and feeling sure that it is utterly incapable of bias or prejudice, Director D. P. Olson of the Idaho State Bureau of Highways has in active operation a system of photographic record keeping which saves time, trouble, anxiety and clerk hire, and yet has proved remarkably efficient.

Settling a disagreement by going over the newly finished road with only a copy of the plan and profile to aid in visualizing what construction difficulties and obstructions had been encountered in the original terrain was once one of the joys to the director of the Idaho Bureau. To add to the hilarity of the occasion, he was usually accompanied by an irate contractor, a distracted resident engineer, and a neutral Bureau of Public Roads inspecting engineer. These controversies rapidly became a serious matter, interfering with the proper functioning of the Bureau personnel, and affecting its relations with the contractors.

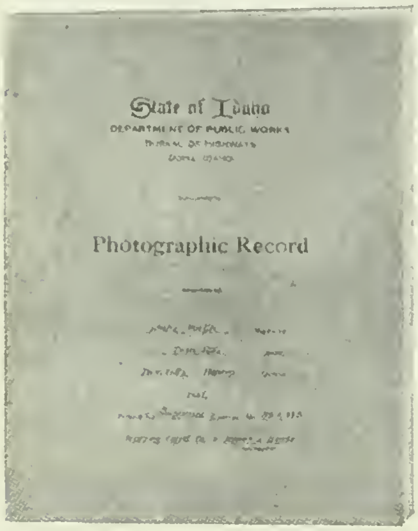
This difficulty could have been handled, of course, by introducing a series of frequent inspections by the director or his representative on each project, making tours so often that the general office could have been intimately informed on all special features to be solved on all projects. The bureau was unable to add to its organization to provide such a system for handling these matters and the records that necessarily would have piled into the central office, and a further difficulty would have been experienced in procuring the type of men necessary in an undertaking of this sort.

Various methods of reports were required from the resident and location engineers in the fall of 1919 in an effort to relieve this situation. Under one of these methods, each location engineer was required to photograph his contemplated line. Special attention had to be given any feature that might lead to difficult construction. Pictures were made of the terrain at these points, giving all the details possible, and these photographs were accurately referenced to the nearest station on the preliminary plan and profile. The advantage of this was immediately recognized, and it became an integral part of preliminary location.

Photo System Has Many Advantages.—It was a natural development that this idea should be carried into construction. As the construction proceeded, further progress in preventing acrid discussion was achieved by further pictures (taken with contractor's knowledge and consent) of various phases of construction as the work went forward. On completion of the work, it followed naturally to complete the circle by photographing the finished sections of the road, particularly the sections that had presented problems in the original plan.

The advantages derived from this system were immediate. It eliminated various other methods that were being tried out and led to a clear understanding of all matters appertaining to each project without increasing inspections or adding to the personnel of the bureau. The instructions to district engineers were immediately changed to include not only the preliminary location survey, but also the photographing of construction phases and the completed sections of each project.

How Records Are Kept.—The photographs, in the records as kept at the present time, are made by the location and resident engineers with a 3-A Kodak, equipped with a special lens to aid in emphasizing detail when necessary. When needed, still larger pictures are made. These are bound in a folder capable of containing about 30 light cardboard sheets and 30 white second sheets. The size adopted for convenience was 9 in. by 11 in. for the inside sheets and 9½ in. by 11½ in. for the folder. The pictures are mounted on one side of the cardboard sheet, each sheet containing two photographs. In the case of pictures smaller than postcard size the number is increased to three. The white sheets serve to protect the photographs as well as to contain explanatory matter pertaining to them. The Idaho office has found this size to be very satisfactory as it permits plenty of space on the white sheet for notes covering the picture opposite, and is still small enough for convenient filing and for carrying in a portfolio. Photographs of the cover and of a typical two-page spread taken from one of these record books are herewith reproduced.



State of Idaho
DEPARTMENT OF PUBLIC WORKS
BUREAU OF HIGHWAYS
BOISE, IDAHO

Photographic Record

Reproduction of Cover of One of Photographic Record Books.

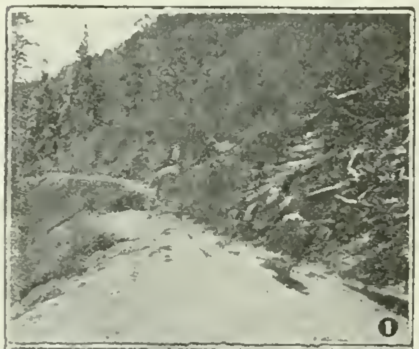
Four photographic records are made of each project. One remains in the file of the district engineer in whose territory the work is done, one is retained for the files of the bureau, and two are forwarded to the district office of the Bureau of Public Roads, one of the latter number to be forwarded to Washington, D. C.

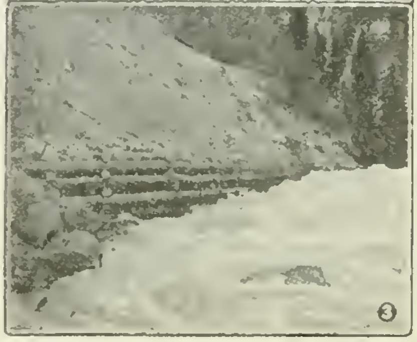
This same scheme is also fully carried out in reconstruction and maintenance. The accompanying pictures numbered 1 and 2, showing the extent of the damage done to a state highway along the north fork of the Payette river south of Cascade, Idaho, by high water and slides which resulted from the spring thaw of 1922, illustrate the use of the system. These photographs were, of course, accompanied by a description of the damage done, with estimates of cost for temporary and permanent repairs.

Picture No. 3 shows the detail of the log cribbing necessary to support the bank and hold it in place. The cribbing is securely anchored at the bottom and logs running back into the bank hold it in position laterally. The ends of the logs driven into the bank are securely fastened to the logs in front by heavy, substantial iron rods.

In the early part of 1920, certain estimates on completed projects were held up for some months while differences between resident engineers and contractors were settled by check surveys run by unbiased engineers. In the absence of a photographic record, this controversy finally had to be settled by conferences held in the central offices of the bureau of highways and, even then, each party had to rely heavily on the other's spirit of fair play. Now that photographs are being made of each phase of the construction as it proceeds, such difficulties cannot possibly arise.

Others Can Profit By This Plan.—These photographic reports have, indeed, proved of value in so many different ways that the Idaho bureau has found them an invaluable addition to the records of each road project which it undertakes. And they can, of course, be made of still further service as the field engineers realize the direct personal benefit they derive from them. This is especially true in preliminary surveys and it is the policy of the bureau to develop this idea as far as it affects economy of grade and design in location





A photographic report of damage done by high water and landslides to an Idaho highway. Photos Nos. 1 and 2 illustrate the damage, while photo No. 3 shows the detail of the log cribbing necessary to support the bank and hold it in place.

Idaho believes that the photographic record is here to stay. Other state highway departments are certain to find that they will save money by equipping their engineers with kodaks and instructing them to "fire at will."

Regulation of Overloading of Motor Trucks.

Paper Presented Nov. 21 at Joint Sessions of North Central Division of National Highway Traffic Association and Michigan State Good Roads Association

By DANIEL C. FENNER.

Manager, Public Works Department, International Motor Co., New York City.

Effective regulation can be accomplished only after careful investigation and determination of the direction and amount of deviation from standards of normal practice. When we attempt to determine the facts regarding the loading of motor trucks we are handicapped by the lack of a standard which can be used as a practical basis of comparison.

A motor truck is a carrying tool but not necessarily a measuring tool. It should be placed in the same general classification with the shovel and the wheelbarrow and not with the quart and peck measure and the bushel basket.

The overloading of motor trucks is due in part to the improper basis of rating and classifying the motor truck chassis in terms of the manufacturer's rated pay load capacity. The user soon learns that this rating really does not mean anything. He purchases a motor truck chassis, attaches a body which may or may not fit either the chassis or the commodity to be carried and he then loads this truck to suit himself.

Motor Truck Body as Real Measure of Capacity.—It would seem, indeed, that the motor truck body is the real measure of capacity which determines the size of chassis which must be used to carry it, loaded with the commodity to be hauled.

In the sale of motor transportation, the successful salesman conducts a careful survey, the results of which convince the customer that a certain type, size, capacity and weight of body is necessary to fill his transportation requirements. He sells his customer this particular type, size, capacity and weight of body and then, and not until then, is he in a position to sell the customer the proper type and size of chassis to carry this body loaded to capacity with the particular commodity that it is purchased to haul.

The large number of misfit motor trucks on the road today are the best possible examples of the other method of selling the motor truck chassis first and allowing the customer to put on the chassis any old body and load it in any old way.

Rated Capacity for Chassis.—Each chassis when it leaves the manufacturer's plant has a definite rated capacity for both the body weight and the weight of the load. If a particularly heavy body is mounted or if various forms of auxiliary power devices are mounted in addition to the body and the dead weight of the body and these power devices exceed the body weight allowance determined by the chassis manufacturer, the pay load capacity must be reduced by the amount of this excess. In the case of dump bodies with hoists and transmission power take off for driving same power-driven winches, pumps, air compressors and various other forms of auxiliary power devices, this excess weight is a considerable amount and in many cases overloading would be reduced if a larger capacity chassis were used.

Manufacturers have suggested that state motor vehicle commissioners should refuse a state motor vehicle license for any truck which is not equipped with a manufacturer's caution plate, properly stamped with the actual weight of the chassis, body and load capacity.

Caution Plates.—Manufacturers are now proposing to go a step forward and indicate on this plate the maximum allowable gross load for the front axle, the maximum allowable gross load for the rear axle, the maximum allowable speed and the distance in which the vehicle loaded to capacity can be stopped with each set of brakes operated independently with the vehicle running at the above maximum speed on a hard, dry, level roadway. The information on this caution plate will give the owner the data he needs for painting the weight and carrying capacity on the sides of the vehicle to comply with the local state law. It will also enable the local enforcement officer to check up the distribution of weight between the axles, the maximum speed and the condition of the braking system. A similar plate for use on home made trucks can be issued by the state motor vehicle department. The information contained on this plate will prevent the operation of improper trucks and force the proper operation of good trucks. It will put the penalty for poorly adjusted brakes and steering connections directly up to the operator where it belongs.

Some states are considering the suspension of a driver's license for three months as a penalty for faulty brakes.

Owner's Excuses for Overloading.—Let us consider briefly the cause of reasoning which the owner follows as an excuse for overloading:

1. Beating the law.
2. Beating the state out of the proper amount of license fees.
3. Beating the rates of a competitor.
4. Beating the purchase price of the truck.
5. Wilful persistent overloading in the face of all the facts.

Let us also briefly consider the result of these practices.

The man who overloads to beat the law ultimately runs afoul the local enforcement officer. The lightest penalty, if any, forces him to leave his excess load alongside the highway and the heaviest penalty forces him to leave his truck and its load with the state authorities until such time as his case comes before the Court and is decided. In some cases, this may require from six to eight weeks. In either of the above cases both the owner and the operator are subject to fine and suspension of license.

The man who overloads to beat the state out of the proper license fee will ultimately have to forfeit his low rating license and the money which he paid for it and be forced to take out a new license based on the gross weight which the truck was carrying at the time of his arrest and at the higher fee. Under the new license, however, he will not be allowed to carry more than the manufacturer's rate of capacity for the vehicle and its tire equipment.

The man who overloads to beat the rate of a competitor finds the practice unprofitable and ruinous in the long run. He does not benefit himself in any way. Rather he is benefiting his customer to whom he makes a present of the depreciation on his equipment.

The man who overloads to beat the purchase price of his truck or say rather to take advantage of the "overload capacity" offered by some truck salesmen is up against the general law of averages. In the end he gets just about what he pays for and no more. You can be sure that the owner who follows this practice keeps no operating costs that are worthy of the name.

The man who persists in wilful overloading in the face of all the facts is a menace to public safety and should permanently be refused either a vehicle or an operator's license. He has forfeited his right to the use of the highway and a few less of his kind on the highway will be a distinct benefit to highway transportation.

Regulation of Loads Would Help Truckman.—Allow me to quote from a statement recently issued by Mr. Joseph F. Whelan, one of the most successful and progressive professional truck operators in New York City:

"With regard to the perpetual statement that the regulation of loads to the manufacturer's rated capacity would put the truckman out of business, I would say that this is not so. Such regulation instead of putting truckmen out of business would help them materially. If it did nothing else, it would bring to a halt the activities of the irresponsible operators who have no regard either for their mortgaged equipment or for their legitimate competitors."

"If truck loads were regulated, it would mean that prices could be standardized and that much equipment that is now idle might be operated at a fair profit because additional trucks would be needed to carry the freight formerly piled haphazardly upon two or three long suffering and much abused vehicles."

Investigations conducted in some of our states show that the light and medium capacity vehicles are overloaded to a greater extent and in greater numbers than the heavy capacity vehicle. This indicates the importance of restricting loads per inch width of tire per wheel and per axle. We must recognize the four classes of tire, pneumatic, cushion, solid rubber and metal, for regulating speed and the determination of license fees according to wheel load. We must restrict the minimum thickness of solid and cushion tires when measured between the tire flange and a flat metal surface on which the wheel stands. We must also take into account the condition of tire.

The safety of the public, the preservation of the highway, the economy of vehicle operation, the status of the operator and the successful and economic development of highway transportation all demand that the practice of overloading should be discouraged, forbidden, prohibited and stamped out completely.

Let every week be a safety week in which we conduct a campaign against overloading. If you are a truck owner and operator give your trucking department very definite instructions regarding proper loading of highway vehicles. If you purchase your trucking on a rental basis, refuse to patronize those professional truckmen who persist in overloading.

Put it up to your local motor truck association to stop this practice of overloading or take the consequences of a concerted action of the local automobile owners' association and the local chamber of commerce to report to the enforcement officers every truck which shows the slightest evidence of being loaded beyond its capacity.

Let us take all the pleasure and the satisfaction out of overloading. Then the chap who has been overloading just to beat the game will quit and the chap who is really forced by circumstances to haul more than the rated capacity of his present vehicle will either buy a larger vehicle or a semi-trailer and mount the front end of this trailer on a fifth wheel attached to the frame of his present vehicle over its rear axle. By this means he can double the capacity of his present vehicle and by distributing his gross load over six wheels, four of which are rolling and only two driven, he can keep within the wheel weight restrictions of the state law and the manufacturer's rated capacity of the truck, help to preserve the safety of the public and the best interests of highway transportation.

The motor vehicle industry stands solidly behind the rigid enforcement of the provisions of the proposed uniform vehicle law and the existing state laws. It condemns overloading and overspeeding unreservedly and will co-operate actively in every movement to regulate loads and speeds of motor trucks on the highway.

Graduate Work in Highway Engineering and Highway Transport

Committee Report Presented Oct. 26 at Second National Conference on Highway Engineering and Highway Transport Education.

In formulating its report, the committee has had in mind the following fundamental principles governing graduate engineering work:

1. The courses should be designed to prepare students to render the service demanded by our social and industrial life.
2. The work should cover a field, beginning at that point where undergraduate work stops.
3. The time at which the work is given should be such that the largest number possible who desire such training can attend.
4. The curriculum should be well co-ordinated as a whole, yet it should be sufficiently flexible to allow students to make special investigations in subjects in which they are interested
5. The results of any noteworthy investigations should be made available to other investigators and the public.

It was realized by the committee that the institution offering graduate work in highway engineering and highway transport in keeping with these principles is undertaking a task fraught with problems.

Although there is an overwhelming demand from the public for men trained in highway transport, the industry is undergoing such radical changes that the demand is not fully chrystalized. The graduate work therefore must be general in scope and fundamental in character.

Highway engineering and highway transport are attracting individuals from all fields. Some are literary graduates who have no engineering training except perhaps pure science, many are graduates in civil engineering who have had no training in highway transport but usually have come in contact with highway engineering to a limited degree, others are engineering graduates who have not even touched upon highway engineering, while some few are graduate highway engineers who perhaps have had more or less experience in the practice of that profession. Graduate work in highway engineering and highway transport, therefore, should deal with the fundamentals, as well as advanced professional practice.

To have courses given during the regular collegiate year only would mean that those attending would have to leave their work early in the fall which is usually the busiest season. Although it is desirable to have regular collegiate courses for those who can give up the time to attend arrangements should be made also to accommodate those who cannot so arrange their time.

Students from active work may desire special instruction in one particular phase of the industry and although he may not be able to attend a course running throughout a semester, he should be able to make the desired specialization.

In view of the foregoing facts, the committee presents the following conclusions:

1. Fundamental courses in highway engineering and highway transport which are open for students to take for graduate credit should be offered in the regular semester courses.

2. This same work and further specialization should be given in a series of two or three-week courses during which time all effort is concentrated on the subject at hand. Hours' credit should be given according to the class-room time spent in each period or on each course.

3. The sequence of courses should be properly arranged so that the subject as a whole is covered logically, and should be arranged in related series so that series of related subjects can be taken consecutively without any idle time.

4. A complete collection of textbook and periodical literature on highway engineering and highway transport should be available and outside lectures should be secured from men who are actively engaged in the industry and who are recognized authorities in the phase of the work upon which they are to lecture.

5. The series of courses offered should embrace the following subjects:

Highway Engineering:

Highway Engineering, Economics, Financing, Management, Organization and Personnel.

Highway Engineering Theory and Design.

Highway Specifications, Contracts, Inspection and Jurisprudence.

Grading Machinery and Operations, and Earth and Sand-Clay Roads.

Gravel and Broken Stone Roads, Dust Prevention and Bituminous Surfaces.

Brick, Cement-Concrete, Stone Block and Wood Block Pavements.

Bituminous Macadam, Bituminous Concrete and Sheet-Asphalt Pavements.

Highway Materials: Production, Advanced Tests and Research.

Highway Srtuctures.

Highway Engineering Seminar.

Highway Transport:

Interrelationship of Highway, Railway and Waterway Transport.

American and English Highway Transport Methods.

Right Transport Economics and Surveys.

Highway Transport Legislation and Traffic Regulations.

Mechanism, Operation and Maintenance of Motor Trucks, Tractors and Trailers.

Highway Transport Management: Administration, Organization and Personnel.

Highway Transport Costs and Record Systems.

Highway Transport Seminar.

6. There should be provided the opportunity to take certain courses to be arranged to meet the needs of any group of students who desire to make worthy investigations in any particular field.

7. State, county and municipal highway departments should co-operate with educational institutions in providing, for graduate students, training and experience in highway engineering and the operation and maintenance of motor trucks.

8. Fellowships should be provided for high grade graduate students by individuals, companies, and state highway departments.

The Trend in Highway Transport Education

A Paper Presented Oct. 26 at the Second National Conference on Highway Engineering and Highway Transport Education

By ARTHUR H. BLANCHARD,
Professor of Highway Engineering and
Highway Transport, University
of Michigan.

What is included in highway transport education? I conceive that highway transport education should cover the fundamentals of the science, art, economics, and business of the transportation of passengers and commodities over highways.

Courses in this field will be taken by men looking forward to the profession of highway transport engineering, the motor vehicle industry, and the businesses of traffic management and highway transport.

In the opinion of some, highway transport may not be considered as belonging to the field of technical training and education. On sober thought, however, it will be seen that this branch of knowledge comes well within the classic definition of engineering embodied in the Royal Charter of the Institution of Civil Engineers of Great Britain, which, in part, as as follows: "The art of directing the great sources of power in nature for the use and convenience of man as the means of production and of traffic in states both for external and internal trade."

From the standpoint of highway transport business, courses in this field will be taken by men who desire to efficiently equip themselves for the positions of business administrators, dealers, salesmen and advertisers in the motor vehicle industry, and executives, operators, traffic managers, motor truck fleet managers, and dispatchers in the commercial field of highway transport, and in the closely related fields of railway and waterway transport.

Demand for Highway Transport Engineers.—What is the demand for highway transport engineer and men equipped for highway transport business? In May, 1920, the First National Conference on Highway Engineering and Highway Transport Education, held in Washington, D. C., unanimously adopted the conclusion that 4,000 men should be trained in highway transport each year in universities for the positions heretofore enumerated. Many have misinterpreted the meaning of this conclusion. Emphasis should be placed on the words "should be trained." The representative committee framing this conclusion had in mind the economic and efficient utilization of highway transport in the transportation system of the United States. They did not say that there was an immediate call for 4,000 trained men each year, but they did imply that the country would be benefited by having 4,000 men trained each year and their services utilized in the field of highway transport.

What is the present situation in regard to the demand for highway transport engineers and men trained in the business of highway transport? While it is true that the University of Michigan, which first instituted courses in highway transport and is in the heart of the motor vehicle industry, has no difficulty in placing its men in the highway transport field, the number of well-paid positions available in this field at the present time is comparatively small. Why does this condition exist? The answer is simple. The potential users of men trained in highway transport are not educated to the value of the services of such men.

Allow me to respectfully suggest that the Highway Education Board devote at least as much time to the spread of propaganda among potential users of men trained in highway transport as in encouraging the univeristies throughout the United States to establish courses in highway transport. A herculean task must be consummated in this field if we are to see highway transport take its proper economic place in the transportation system of America.

Highway Transport Divisions in State Departments.—Many highway departments are not properly designing the highways for even immediate future traffic because their personnel does not include men who have had a proper training in highway transport to have a vision and adequate background which will enable them to diagnose the probable development of traffic on a given highway, or, in other words, to make the prerequisite of economic highway design, a highway transport survey, which embodies all investigations in the field and office which are necessary to efficiently estimate the probable amount, character and effects of the future traffic which will use a given highway during the lives of its several component parts.

The establishment of a sound highway transport business is based on the results of an exhaustive transport survey. Why should not the same policy be followed when the economic investment of millions of dollars in highway improvements is at stake?

In order that highway transport surveys should be properly conducted and adequate provision be made for the economic design, construction and maintenance of highways, each state highway department should create a highway transport division. The duties of this division would be to deal with all matters pertaining to traffic and transportation which affect the economic design and maintenance of highways and their efficient use by pedestrians and all classes of vehicles. One of the most important functions of such a division would be to make highway transport surveys as preliminary to the design and redesign of state highways, the determination of efficient methods of maintenance, and the formulation of recommendations pertaining to efficient traffic and transport regulations.

Qualifications of Men in Highway Transport Division.—Men assigned to a highway transport division should be experienced highway engineers who have or are rapidly acquiring a knowledge of the following subjects: highway transport economics, legislation, surveys and methods; highway transport management, including delivery systems, scheduling and routing; traffic regulations; interrelationship of highway, railway and waterway transport; port, terminal and warehouse facilities; and the fundamentals of the mechanism and operation of automobiles, motor trucks, tractors and trailers.

In order to secure and retain the services of engineers qualified to occupy responsible positions in a highway transport division, it will be necessary for state highway departments to pay salaries ranging from $3,600 to $10,000. Not only will the economic law of demand and supply in the highway engineering field necessitate the payment of proper salaries to engineers trained and experienced in highway transport, but highway departments will be forced to compete with the commercial demand for the services of such men.

Highway Transport Engineers as Salesmen.—Motor truck manufacturers' organizations are in a chaotic condition from the standpoint of the proper utilization of men trained in highway transport. Why? In general, they have followed in the obliterated footsteps of companies manufacturing highway machinery and materials. The latter companies originally established departments which were advertised to give unbiased consulting service to their customers. Motor truck companies established a few years ago highway transport engineering departments and advertised to make a complete highway transport survey covering the requirements of a prospective user of motor trucks and to give unbiased advice pertaining to the purchase of equipment. What was the result? In the first place, it was found impracticable to divorce unbiased opinion from the commercial interests of the organization represented and soon prospective customers began to realize this self-evident fact. Second, disastrous conflict arose between the highway transport engineering department and the sales organization, a natural result to anyone familiar with the interrelationship existing between the activities of such departments. What was the final outcome in the case of companies manufacturing highway materials and machinery? The natural logical conclusion was reached that the sales organization should contain men trained in the fundamentals of highway engineering practice and the efficient use of the machinery or materials manufactured by a given company and that advice should be restricted to the efficient and economic utilization of the machinery or materials manufactured. The results have been beneficial not only from the standpoint of the commercial organizations concerned but also from the standpoint of the general highway engineering profession and the public, which ultimately is benefited by increased efficiency. All are familiar with the efficient services rendered along these lines by such commercial organizations as The Asphalt Association, the Barrett Company, the Granite Block Manufacturers' Association, the Jennison-Wright Co., the National Paving Brick Manufacturers' Association, the Portland Cement Association, the Texas Company and many others. I predict that in the near future the motor truck manufacturers of this country will see the light and follow in the footsteps of the closely related companies who have already passed through the transition stage. Concretely stated, the sales organizations of motor truck, tractor and trailer companies should be composed of men trained in the fundamentals of highway transport and the efficient use of the equipment manufactured by the company which they represent.

Engineers in Operating Organization of Highway Transport Companies.—Failures of highway transport enterprises are occurring every day due to a lack of knowledge of the fundamentals of the economics, science and art of highway transport. It is reported that 90 per cent of all highway transport companies doing business with New York City as a center fail within three years after entering this field. While 50 per cent may fail due to cut-throat competition by fly-by-night companies, it is conservatively estimated that at least 50 per cent fail because of lack of knowledge of the A B C's of efficient highway transport business methods, cost accounting, management, and operation and maintenance of equipment. The highway education board has a big task before it in bringing to the attention of groups of business men or capitalists, operators and prospective operators of highway transport, the necessity of having connected with their operating organizations men who are thoroughly trained in the methods of highway transport, the inter-relationship of highway, railway and waterway transport, highway transport legislation, the fundamentals of highway transport cost and record systems and the principles of highway transport management, together, of course, with a knowledge of the mechanism, operation and maintenance of motor trucks, tractors and trailers.

Status of Highway Transport Education.—We find a satisfactory status relative to the development of highway transport education in the universities throughout the United States. In some institutions, the logical development occurs by the men having charge of highway engineering courses giving courses in the related field of highway transport. In other institutions, such courses are offered by the department of economics or business administration. If these departments are to efficiently teach highway transport, the instructors must have a knowledge of the fundamentals of the economics and science of highway engineering and practical highway transport. It is expected that notable developments will take place along these lines especially when authoritative texts are available. We have a development in the main of undergraduate instruction in the fundamentals of highway transport. In this connection, allow me to strongly emphasize a recommendation which I have made at the University of Michigan that all engineers should be required to take, as a part of their curricula, a fundamental course in "transportation" which would cover the economics of the utilization and operation of highway, railway and waterway transport.

Naturally, developments in the graduate field have been slow, due first, to a lack of demand by students for such courses; second, because there are few instructors who feel capable of giving graduate instruction in this field; and third, due to a lack of the necessary financial support by institutional administrators.

Highway Engineering and Highway Transport Courses at University of Michigan.—As soon as the demand from potential users develops, it will be necessary to materially speed up the training of mature men as well as college students in the fundamentals of highway transport. It is my belief that the graduate short period course offers the most efficient method of training mature men who may be connected with motor truck or trailer manufacturers' promotion and sales organizations; traffic departments of plants, factories, wholesale and retail stores, steam and electric railroads, and waterway transportation companies; highway transport enterprises; and state, county or municipal highway departments. Such courses in the field of highway engineering and highway transport are developing rapidly at the university, which I have the honor to represent. Eighteen of these courses are given in periods of two weeks each during the months from December to March inclusive. Each course consists of 30 lectures, or the equivalent thereof, and counts as two hours' credit towards the total of 24 hours required for the master's degree. Persons of mature age, who do not hold collegiate or technical degrees, may register for these courses as special students, not candidates for a degree. In the first year, 1919-1920, when such courses were offered at the University of Michigan, the attendance was 29. In 1920-1921, the attendance increased to 45, while in 1921-1922, 94 men were registered in these courses, the average age of the men being 27 years, ranging from 22 to 54 years. They came from all over the United States, and some from foreign countries. They represented universities; state, county and municipal highway departments; consulting engineers' offices; contractors' organizations, companies manufacturing motor trucks, highway machinery and materials; and from the field of highway transport business. About 50 per cent of these men were graduate engineers registered in the graduate school for the master's degree, 16 master's degrees being awarded in June, 1922, to men with a major subject in highway engineering or highway transport. The other 50 per cent were mature men in practice who had not had a college training. It should be stated that all men are on an equal footing in these graduate courses and take an equal part in the discussions of the many subjects considered.

In this connection, I wish to reiterate my recommendation at the 1920 conference that at least 10 universities, located in different geographical sections of the United States, offer graduate short period courses covering the various phases of highway transport, if they are financially able to engage the proper personnel and provide sufficient equipment for carrying on graduate work in this field. It is earnestly hoped that this recommendation may be favorably considered by administrative bodies of some leading universities and that they will adopt the broad-visioned policies of Dr. Marion L. Burton, president of the University of Michigan, and the Board of Regents, who have provided adequate personnel and physical equipment for the efficient development of graduate instruction and research in highway engineering and highway transport as shown, first, by their atction in establishing a chair of highway engineering and highway transport, and appointment of two assistant professors, a librarian of the Davis Library of Highway Engineering and Highway Transport, an instructor and three assistants in highway engineering, and, second, in their assigning two floors of one wing, 65 ft. by 225 ft., of the new $750,000 Engineering Bldg., to the division of highway engineering and highway transport.

To Make General Plan of Island of Montreal.—Preparation of a general plan of the island of Montreal is about to be started. While the exact details of the plan have not yet been determined, it is learned that a general plan would mean a topographical survey of all the streets, street car lines, parks, hydrants, sewers, underground conduits, water pipes, gas pipes, street and sewer levels. It is expected that from six to eight years will be required to complete the plan, at a probable cost of from $200,000 to $300,000.

Federal Aid Highway Systems in 8 States Approved.—Systems of Federal aid highways designated by the State highway departments of Maryland, Arizona, Montana, Colorado, New Mexico, Wyoming, Idaho and Vermont have been approved by the Secretary of Agriculture.

A Canadian Report on Classification and Remuneration of Engineers

The Council of 1920 of the Engineering Institute of Canada approved the establishing by the Institute of rates of remuneration for its members both by fees and by salary. A committee on classification and remuneration of engineers was constituted by resolutions by the Council. The final report of the Committee on the annual compensation of beginners and the classification of those not in consulting practice is printed in the November Journal of the Institute. The portion of the report relating to fees for special work, particularly that of a consulting engineering nature will be prepared in the immediate future. The report practically in full follows:

Classification.—The Committee realizes that the first essential towards any concerted or general effort on the part of the engineering profession in Canada towards proper compensation for its services is a standardized classification with accompanying rates of remuneration. It has, therefore, been the main purpose of the committee to evolve an appropriate classification and scale of remuneration. After a careful study of the several reports, that proposed by the Engineering Council recommends itself to the committee and, with some alterations, has been adopted as the basis of this classification. The subdivision into professional and sub-professional service has been discarded as it was felt to be impossible to draw any marked distinction between them, and that there was no advantage in doing so. This required a certain revision of grades V, VI, and VII in regard to duties and qualifications. Another slight revision has been made to give the college graduate less advantage over the non-graduate with experience for the first year or so after graduation, and a greater advantage thereafter until the higher positions are reached. It is felt that for the higher positions a fixed difference in years of experience between the graduate and non-graduate is purely academic but the Engineering Council periods have been retained.

While the names attached by the Engineering Council to the different grades in the classification have been retained, it has been oily for the purpose of identifying the different grades by association with a name; the name attached to an engineering position need not necessarily be an indication of the grade that would be accorded that position in this classification. The name of chief engineer of a small industrial concern or a small municipality might correspond to grade V or VI in the matter of duties and qualifications. It should be possible, however, from the nature of the duties required and the qualifications demanded for any position, to assign that position to its proper grade in the classification. The list of positions given corresponding to each grade is merely suggestive.

Chief Engineer: There are certain engineering positions of great importance which require men of the highest engineering ability and training and executive attainments and the occupants of such positions the Committee has given the title of Chief Engineer. Such positions are considered as being outside the scope of engineering classification.

The classification prepared by the committee is as follows:

Grade I—Assistant Chief Engineer.

Duties.—To act in administrative charge of a technical organization, or of a main division thereof; to determine the general policies of the organization under the limitations imposed by law, regulation or other fixed requirements; to have final responsibility for the preparation of reports, cost estimates, designs, and specifications and for the construction, maintenance, or operation of engineering works or projects; to have full charge of the collection and presentation of data for the conduct of valuation proceedings; to conduct or direct the most comprehensive lines of engineering research.

Qualifications.—Training and experience of a character to give substantial evidence of engineering knowledge and ability or of executive capacity of highest order along lines of work similar to those involved in the position to be occupied and of at least twelve years' duration of which at least four years shall have been spent in work of a similar character in a subordinate position, and at least five years in responsible charge of important work or projects. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing, or, in the absence of such degree at least four years additional experience. The completion of each year of such standard course shall be considered the equivalent of one full year of such additional experience.

Positions Corresponding to This Grade.—Assistant Chief Engineer, City Engineer, Superintending Engineer for a Province, etc.

Grade II—Engineer

Duties.—Under general administrative direction and within the limits of the general policies of the organization, to have responsible charge of and to initiate and determine policies for a major subdivision of an organization; to prepare for final executive action reports, cost estimates, designs, specifications, and valuation studies and data; to have immediate charge of the construction, maintenance or operation of engineering works or projects of major importance; to conduct or direct major lines of engineering research; or to furnish for execution action expert or critical advice on engineering works, projects or policies.

Qualifications.—Active professional practice or executive charge of work for at least eight years, of a character to demonstrate a high degree of initiative and of ability in the administration, design, or construction of engineering works or projects of major importance, of which at least three years have been spent in work of a similar character in a subordinate position and at least three years in responsible charge of work. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing, or, in the absence of such degree, at least four years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Positions Corresponding to This Grade—Engineer, District Engineer, Designing Engineer, etc.

Grade III—Senior Assistant Engineer

Duties.—Under general administrative and technical direction to be in responsible charge of an intermediate division of an organization; to exercise independent engineering judgment and assume responsibility in studies and computations necessary for the preparation of reports; cost estimates, designs, specifications or valuations; to have immediate charge of the construction, maintenance or operation of important engineering works or projects; or to conduct or direct important lines of engineering research.

Qualifications.—Active professional practice or executive charge of work for at least five years, of which at least three years shall have been spent in work of a similar character in a subordinate position, with at least one year in responsible charge of work. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing, or in absence of such degree, at least five years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Positions Corresponding to This Grade.—Senior Assistant Engineer, Division Engineer, Engineer of a Department.

Grade IV—Assistant Engineer

Duties.—Under specific administrative and technical direction, to be responsible for the conduct of the work of a minor subdivision of an organization, to collect and compile data for special items of engineering studies; to take immediate charge of field survey projects and of the design and construction of engineering work; to lay out and develop work from specifications and to supervise the work of draughting or computing force; or to conduct specific tests or investigations of apparatus, materials or processes.

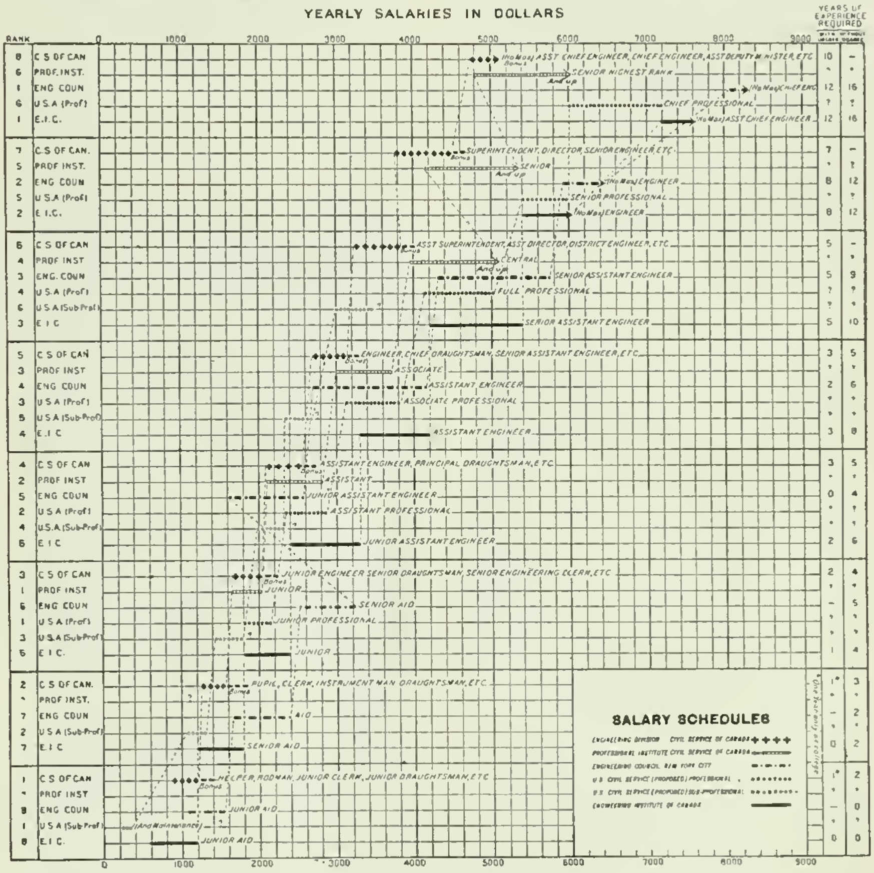
Qualifications.—Experience for at least three years of which one year shall have been spent in duties of a similar character in a subordinate position. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing, or, in absence of such degree, at least five years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Positions corresponding to this grade: Assistant engineer, estimating engineer, chief engineering draughtsman, engineer on construction, etc.

Grade V—Junior Assistant Engineer.

Duties.—Under immediate supervision to take charge of squads in draughting office: to direct work of field party on surveys or construction; to direct the work of computing surveys, estimates; to design minor engineering works; to compute and compile data for reports of records; to investigate minor details of engineering work; to perform tests of apparatus, material or processes; to have charge of inspection of engineering works under construction.

Qualifications.—Experience for at least two years in duties of a similar character in a subordinate position. Fundamental training equivalent to that represented by professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing, or, in absence of such degree, education equivalent to graduation from a high school and at least four years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.



YEARLY SALARIES IN DOLLARS

Comparison of Salary Schedules for Various Engineering Positions.

Positions corresponding to this grade: Junior assistant engineer, inspecting engineer, etc.

Grade VI—Junior

Duties.—To supervise the plotting of notes and maps, to perform work involving the use of surveying, measuring and draughting instruments; to take charge of parties on survey or construction work; to design details from sketches and specifications; to compute and compile data for reports or records; to inspect or investigate minor details of engineering work; to supervise construction or repair work; to check plans, surveys and other engineering data.

Qualifications.—Experience for at least one year in work of a similar nature in a subordinate position. Fundamental training equivalent to that represented by a professional degree granted upon the completion of a standard course of engineering instruction in an educational institution of recognized standing, or, in the absence of such a degree, education equivalent to graduation from a high school and at least three years of additional experience. The completion of each full year of such standard course shall be considered the equivalent of one year of such additional experience.

Positions corresponding to this grade: Senior draughtsman, inspector, etc.

Grade VII—Senior Aid.

Duties.—To prepare general working drawings where design is furnished; to plot notes and prepare maps; to design simple structures; to make computations and compile data for reports and records; to prepare routine tests of apparatus or materials; to run surveying instruments and to adjust and care for same; to compute surveys and estimates; to make minor engineering computations; to inspect incidentally construction or repair work.

Qualifications.—Experience for at least two years in work of a nature to qualify for this grade. Education equivalent to graduation from a high school and familiarity with the use of the slide rule and of logarithmic and other simple mathematical tables. The completion of each full year of a standard course in an educational institution of recognized standing shall be considered as the equivalent of one year of the experience otherwise required.

Positions corresponding to this grade: Draughtsman, leveler, transitman, etc.

Grade VIII—Junior Aid

Duties.—To trace and letter maps and plans; to make simple drawings from sketches and data; to make minor calculations; to run tape or leveling rod; to perform other miscellaneous subordinate duties in survey party in field or office, as directed.

Qualifications. — Education equivalent to graduation from a high school.

Positions corresponding to this grade: Tracer, chainman, rodman, etc.

Remuneration.

In arriving at a scale of remuneration, the committee has paid particular attention to the report of the

Branches of the Engineering Institute as representing the opinion of the members of The Institute thrqughout Canada as to what would be a reasonable rate of compensation for engineering services in salaried positions. These reports show a very wide range in the salaries proposed, especially in the higher grades and the variation does not appear to be a question of location or the section of the country in which the report was made. The difference of opinion of different groups of men is very well exemplified by the report of the Vancouver Branch where the scale of remuneration proposed by a committee appointed by the Branch was raised from fifteen to twenty per cent for the intermediate grades at a general meeting of the Branch.

In this report no attempt is made to give different salary schedules for different services such as "Railroad," "Municipal" or "Industrial." Duties of the same nature, or work of the same grade should command the same remuneration, other conditions being the same, whether the work is being done in the service of a railroad, a municipality or an industrial concern. The range between minimum and maximum in the salaries suggested allows latitude for the difference in the abilities of occupants of the same position in the lower and intermediate grades. Your committee feels that it would not be warranted in suggesting salaries for the higher grades beyond stating what it thinks to be a reasonable minimum.

While the rates of remuneration proposed in this report may seem too low to many of the members of The Institute, the committee felt that it would be advisable to be moderate in the first scale, that there would be danger of defeating the object for which the schedule is designed if too high a rate were proposed. Demands to an employer which to him seem unreasonable will receive but slight consideration. Nor can there be any hope of making a schedule effective if it is so high that many of the members of the profession who are not members of The Institute would be satisfied to accept positions at a lower salary than that proposed by the schedule.

On the other hand the committee is of the opinion that the salary ranges for the different engineering positions in the Dominion Government service are inadequate for the professional qualifications exacted. It would seem that adjustments should be made either to give higher salary ranges for the present specifications, or reduced qualifications for the present salary ranges if it desired to attract and retain a staff of properly qualified engineers in the Government service.

The following table gives the grade, years of experience, with and without a college degree and the proposed minimum and maximum salaries for each grade

Grade	Title.	Years with degree.	Years without degree.	Salary, minimum.	Range, maximum
VIII	Junior aid	0	0	$ 600	$ 1.200
VII	Senior aid	0	2	1,200	1,800
VI	Junior	1	4	1.800	2,400
V	Junior assistant engineer	2	6	2,400	8.300
IV	Assistant engineer	3	8	3.300	4,200
III	Senior assistant engineer	5	10	4.200	6.400
II	Engineer	8	12	6.400	No limit
I	Assistant chief engineer	12	16	7,200	No limit

The committee consisted: Chairman, A. H. Harkness, M. E. I. C., Consulting Engineer, Toronto; secretary, Frederick B. Brown, Consulting Engineer, Montreal; J. B. Challies, Director of Water Power, Dept. of the Interior, Ottawa; A. R. Decary, Superintending Engineer, Prov. of Quebec; E. R. Gray, City Engineer, Hamilton, Ont.

The First Concrete Road*

By W. A. GILLETTE.

It has been repeatedly asked: "Where and when did the concrete highway originate?" I think Los Angeles county can justly claim the honor of being the father of the concrete highway, at least so far as the extensive use of this type of pavement is concerned.

It was in 1908 when serving as a member of the Los Angeles County Highway Commission that I prepared specifications calling for this type of pavement on three sections of our county roads; it was with much apprehension that they were adopted and no little anxiety attended the outcome of their execution. It was a decided departure from established procedure and the engineers were strong in their opposition, basing their arguments on the fact that we were using an untried material for paving.

The success of these sections, however brought about the adoption of "the concrete pavement" by the California Highway Commission and in rapid succession other counties, cities and states adopted concrete as their standard with the result that today there are many miles of concrete roads throughout the United States.

Highway engineers realized that macadam roads and other plastic pavements would not withstand the rapidly increasing automobile traffic and the innovation was accepted as the answer to an extremely perplexing problem. It was not realized then what a revolution was just ahead of us in so far as the mode of highway traffic was concerned and even now, with our improved methods and engineering practice, it promises to be a difficult problem to keep pace with the ever increasing vehicle loads.

Our association can do much to help the construction industry attain and retain its proper position in the industrial life of our country by resenting the unjust attacks of bombastic critics against the highway engineers and highway contractors when some section of highway fails. These attacks are generally prompted by some ulterior motive but are usually accepted by the public as just and competent criticism.

If the present practice of nsing our highways as roadbeds for common carriers at the expense of the taxpayers is to continue, without limit as to loads imposed thereon, we must reconcile ourselves to one of two things, an expensive maintenance department or an enormous initial cost in an attempt to anticipate the burden of this ever increasing traffic.

Relief from this condition is to be found in a carefully prepared and properly enforced statute limiting traffic loads so they will not exceed the maximum loads for which our highways are designed or may be designed.

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*From the Oct. 1 News Letter of the Southern California Chapter of the Associated General Contractors of America.

Highway Costs in Montana for 1920-1922

Construction costs of highways in Montana in 1922 were lower than in previous years, according to Montana Highway News, the official publication of the State Highway Department. Although the standard of gravel surfacing for 1922 has been considerably raised and widths of surface and road have been materially increased, the average cost per mile is still under the costs of 1920, although the improvements in design have increased costs per mile over 1921. Substantial reductions are shown in the unit price for all excavation items as compared with 1920. Common and intermediate excavation also shows a lower price than 1921, but rock excavation shows a slight increase.

Prices for common and rock excavation as shown by the 1922 contracts are but slightly over 50 per cent of the price for these items for 1920. Intermediate excavation has also shown a substantial reduction. The reason for the decided reductions are attributable to three main factors: (1) Labor and equipment costs are lower and loanable funds are more readily available; (2) Contractors are more familiar with the class of work; (3) Uncertainties of construction have been greatly decreased. Excavation costs showed a decided decrease in the earlier contracts let in 1922. Later contracts, however, have shown a slight increase.

The following tabnlation shows the average costs for the three years:

	1920.	1921.	1922
Graded roads—Cost per mile	$6,715	$9,430	$6,268
Gravel roads—Cost per mile	8,415	6,270	8,150
Common excavation—Per cu. yd.	.57	.41½	.29⅓
Intermediate excavation — Per cu yd.	.95	.59	.56
Rock excavation—Per cu. yd.	2.05	.93½	1.04
Gravel surfacing—Per cu. yd.	3.00	2.62	2.64

The average cost per mile for graded and gravel roads contracted in 1922 is $7,977 per mile. Of this mileage 72.3 miles have surfaces of gravel or crushed rock at an average cost per mile of $8,150, and 7.36 miles have been graded only at an average cost of $6.268 per mile. In addition contracts have been let for 2.41 miles of paved street at an average cost per mile of $55,638.

Gravel costs show an average unit price per cubic yard of $2.40 for 1922 as compared with $2.62 for 1921 and $3.00 for 1920. Early in 1922 the standard specifications under which all gravel roads are built were so revised as to require the use of a comparatively large percentage of crushed material and the maximum size of material allowable was rednced from 1½ in. to 1¼ in. It was also reqnired that the material be laid on the road in 2 courses, each of which must be rolled. These changes in gravel specifications mark a significant advance in gravel road construction in the state and it is gratifying to the department to note that they have resulted in no increase in cost over 1921.

Grading projects constructed in 1921 represented difficult and unusually expensive work which accounts for the apparent high cost per mile for this class of work over the years 1920 and 1922.

Street Lighting from Illumination Standpoint

General Principles of Obtaining Desired Street Illumination of Different Sections of Cities Outlined in Paper Presented at Convention of Canadian Association of Municipal Electrical Utilities.

By R. M. LOVE.
Street Lighting Specialist, Canadian General Electric Co., Ltd.

Up to 1914 incandescent street lighting was confined to smaller towns and outlying districts where high intensity was not needed. There was a great number of cities utilized incandescent lamps for lighting their downtown sections by using the three or five light clusters. In fact this system was extremely popular for a period in both Canada and the United States. It was the only means of increasing the intensity previous to the development of the large, high efficiency incandescent lamps. These clusters were considered ornamental and efficient at the time; then came the development of the large gas filled high efficiency lamps ranging now up to 1,500 C. P. in the series type for street lighting. With this advancement the day for cluster lighting came to an end; when we compared its ornamental features with a stately single unit it had no comparison; when maintenance was considered, the single unit naturally was by far the most economical. When we take into account efficiency the single lamp is far the more efficient than a number of lamps with the same amount of candle power or wattage. There is also less glass-area to absorb light and no arms to obstruct light.

This brings us up to the present day when we can utilize a modern efficient arc lamp which is still used extensively in the states and some of the larger cities in Canada or a high efficient incandescent lamp for all phases of street lighting.

Problem of Lighting Various Streets—To illustrate the problem we are confronted with when considering street lighting, we will assume we have a city of about 75,000 to 100,000 population. This will then cover most every phase. It can be divided off in the following sections: Main downtown section (white way lighting); secondary business streets; main residential districts, boulevards and parkways; suburbs; highways leading out of city. We will first take the whiteway district. This being the main business district it calls for ornamental lighting. The type of unit and standards to be chosen, when possible, should be of such a design so as to harmonize with the architecture of the buildings. Then intensity of illumination should be such as to flood the street with light, having an intensity of from .25 to 1 ft. candle, according to the density of traffic. Height of units ranging from 15 to 18 and in some cases 20 to 25 ft. Spacing 100 ft. opposite-utilizing 1,000 C. P., or 1,500 C. P. lamps.

Where the main street is built up of buildings of fine architectural quality it is usual to allow the light to flood the sides of the buildings as well as the street surface, a large portion of the light striking the building fronts will be reflected back to the street surface; this varying according to the nature of the building. Where the buildings are not high and it is considered advisable not to illuminate them to a high intensity, refracting glassware should be utilized in the unit and thereby affording longer spacing. If the unit is utilized without refractors, care should be taken to choose the proper glassware so as to obtain the required amount of diffusion and at the same time not lose 40 to 50 per cent of the light in transmitting it through the glass. This I might say is a study of today, for the illuminating engineer. Within the last year or so new glassware has been developed, designed with minute proturbances and depressions on the outer surface. This diffuses the light by breaking it up, also by adding an outer flashing of opal. Here you have an effect never obtained before in street lighting as it adds a pleasing sparkle to the light source.

Where refracting glassware is necessary a dome refractor can be utilized in this new type of glassware without casting a shadow on the globe owing to the light source being broken up by the rippling on the glass.

Results From Whiteway Lighting.—The results obtained from up-to-date whiteway lighting are as follows:

The cosmopolitan atmosphere and dignified effect of the standards by day as well as night.

The minimized window reflection on account of height of units.

High intensity and uniformity of distribution of light on street.

People attracted down town at night, aiding the merchants to display their goods.

An impression planted in the minds of visitors to city which will never be forgotten.

Secondary business street, utilizing a similar design, but perhaps a small unit and lamp, refracting glassware and longer spacing is recommended. This will still maintain an even distribution but with a lower intensity than that of the white way. The mounting height should be maintained not lower than 15 ft. high, average hor. illumination should be from .10 to .25 foot candles, spacing 125 to 150.

Main Residential Streets, Boulevards and Parkways—When we come to consider this phase a very difficult problem usually confronts us, mainly to the trees which we have on our residential streets and boulevards. We must not do away with the trees of course, as really having the trees is the only way of taking away the business air and endeavoring to obtain the boulevard effect, thus making desirable residential quarters. The trees also serve as a shade as well as beautifying. However, if these streets are to be illuminated to the degree that is necessary, taking into consideration the traffic that is on them, which is heaviest in the evening, it is important to at least endeavor to keep the shade trees well trimmed. It will also be necessary to keep the branches well trimmed to a heigth at least 12 to 13 feet above the ground. Of course this will not be necessary on the younger trees.

Where an ornamental system is to be installed such as you find in some of the higher class districts where the ratepayers are willing to pay the cost, which is really small, spread over a number of years, also along driveways and parkways, it was usually found in the past that a short post anywhere from 9 to 10 feet was used, utilizing a ball globe. Short spacing between units had to be used and even at that the intensity on the road surface was very low, as over 50 per cent of the light was lost in the trees.

To accomplish the desired effect the units should be mounted at least 12½ to 13 feet high, in fact if the trees are not too thick it is desirable to mount them as high as 15 feet. The spacing can be 100 to 200 feet, on the staggered or opposite layout, providing the correct glassware is used and either a 400 or 600 C. P. lamp utilized. Here we have an ideal application for refracting glassware, in fact to obtain illumination on the road surface so as to make driving entirely safe, refracting glassware is absolutely necessary. The type of unit to be chosen will depend on the amount of money available.

The lantern type of unit is becoming very popular today for all classes of lighting, but especially for driveways and residential quarters. Its initial cost will be slightly higher than that of the usual glass globe but its maintenance will be considerably lower and from an architectural point of view it suits the surroundings. The dome refractor can be readily used in conjunction with the lantern providing rippled or stippled glass panels are used. This glass can have a slight flashing of opal in it without nulifying the effect of the refractor. However, if it contains too much opal the light source will be given a yellow appearance which is not altogether desirable. The whiter the light the more pleasing and efficient.

If a glass globe is to be utilized it should be made up of glass which has diffusing qualities in it and at the same time designed so as to accommodate a refractor. To accomplish this, stippled or rippled glass should be used, otherwise the effect of the refractor will be killed and a bad shadow will be cast on the globe. The design of standard should be neat and simple, along slender lines.

Where there is an over-head system to be used, bracket type units can be neatly arranged suspended from existing pole lines or center span suspension can be utilized, where trees have grown up on both sides almost forming an arch-way across the roadway, as can be found in many cities. This is really the only efficient means of obtaining light on the roadway. Here also refractor is absolutely necessary.

As we get out in the suburbs wider spacing can be utilized, 200 to 300 ft. or if the blocks are not much longer than this, units can be suspended at each intersection. Here also we can readily see the importance of refracting glassware. Still another type of lighting for suburbs is the ordinary bracket and porcelain enameled reflector. This type of lighting has had its advancements also; the reflector being made with a longer neck lowering the reflecting surface nearer the filament of the lamp.

Lighting Highways.—When we come to the highway we once again have a problem which has baffled the illuminating engineer until within the last year or so. Up to the present time here in Canada we have not bothered with the lighting of our highways only for half a mile or so leading in and out of our towns and cities, and this will be found in most cases, very inefficient lighting usually an 80 or 100 C. P. lamp with an enamel reflector spaced 400 and 500 feet apart. The problem that was to be met was this; a suitable luminaire that would throw the light only on the road surface, utilizing long spacing and a moderately small lamp, otherwise owing to cost it would be impracticable to illuminate the highways.

This condition is now being met with the new parabolic highway lighting unit. This is absolutely the latest addition to street lighting. This unit consists of small reflector screens typically shaped and assembled that they do the work of an ordinary 15 ft. reflector. The light from this unit is directed only along the road surface. This unit should be mounted 30 ft. high, which is usually practicable on existing pole lines along our highways and a 250 C. P. lamp utilized. The units should be spaced 300 feet apart for the main highways where traffic is heavy and on secondary highways this can be increased to as long as 600 feet still maintaining better illumination on road than that of the usual reflector.

The Main Problem in Highway Lighting.—The main problem which we are confronted with in regard to highway lighting is, who is going to pay for it? The towns and cities will not extend their lighting outside their limits, in most cases, and it therefore looks as if it is up to the Department of Highways in our government to take care of this lighting. In the United States steps have been taken in this respect. The New York state has just passed a bill providing for lighting the highways in the cost of repairing and construction of highways. Other states are doing the same thing. This seems to be the only solution and when a comparison of the cost and maintenance of highways is made with the cost and maintenance of lighting, the lighting end is so small that it is really only a drop in the bucket.

When we consider the number of accidents at night along our highways it goes to show that the sooner we come to the lighting of them the better for all concerned.

Regarding the system recommended for highway lighting, I would like to say a few words on this before leaving the subject. It is recommended that a series system be used whenever possible. The units can be fed from pole type constant current transformers which can be operated by time switches. It will be found that the maintenance of a series system will be lower than that of a multiple system, as the life of the series lamp is usually longer than that of a multiple system. However if this type of lighting is to be utilized where a multiple system is already in use, the unit can be very successfully operated by using a 200 watt multiple lamp.

Significance of Some Road Material Tests

Points Which Should Be Borne in Mind When Interpreting Results of Test Data Outlined in Paper Prepared for 1922 Meeting of American Society for Municipal Improvements

By F. H. JACKSON,
Senior Assistant Testing Engineer, U. S. Bureau of Public Roads.

The art of testing road materials has by no means attained the perfection of an exact science. Some of the tests now in use were first proposed and adopted many years ago when the necessity for adequate preliminary research was not realized quite so much as it is today. The result is that certain tests have been firmly established by custom and long usage which are admittedly weak in some particulars. The so-called Deval abrasion test for rock and the "tensile strength ratio" determination for concrete sands are typical examples. Because these tests are not technically perfect, however, is no reason why they should not be used. They can be made to serve a very useful purpose, provided the engineer understands wherein the tests are weak and makes due allowance therefor in his interpretation of the results.

The very rapid changes within the past few years in the design and types of pavements in use, caused by changes both in the volume and character of traffic, likewise continually call for modifications in testing methods to meet new conditions. As an illustration of this point, the cementation test for rock may be cited. This test was used quite extensively in the days of water-bound macadam road construction but is now practically obsolete. The standardization of tests is at best a slow process and when one considers the frequency with which new conditions arise, it is not surprising that some of our methods of tests have failed to attain the perfection which certain critics seem to expect.

Availability of Material.—Another point which is overlooked frequently in studying test data is the question of availability of material. Although this is a matter primarily for the specification writer, experience has shown that many specifications contain requirements which can not be met with any available material. It is well, therefore, that the engineer be familiar with the range in quality as shown by test results of all materials which could compete with those which he is examining.

Looking at the proposition from another angle, a third essential requirement is that he be familiar with service results obtained with materials similar to those in which he is interested. This particularly applies to such naturally occurring products as rock, sand, gravel, etc. The proper selection of such materials in any case can only be made by studying the test data in the light of all of the service indications which it is possible to obtain. Likewise, in the examination of tests of manufactured materials such as Portland cement, paving brick, etc., it is desirable that the engineer know something of the previous service and characteristic weaknesses, if any, of the particular product he is investigating. For instance, he may know of a certain mill which may be grinding cement so as just to pass the specifications. He would naturally scrutinize results of fineness tests on this product more carefully than where he is reasonably sure from past experience that the mill is well within the limit.

It will be seen from the above that to pass judgment intelligently on the results of laboratory tests is not quite so simple as might be supposed. Summing up briefly, anyone who would make the best use of such information must know enough about the methods of tests employed to be able to apply reasonable tolerances, he must be familiar with the general character and range in quality of all available materials, and he should know something of the previous service rendered by similar materials in the type of construction involved.

A brief discussion of some of the more commonly used nonbituminous road materials along the lines suggested above follows:

Portland Cement.—Portland cement is probably the most universally used of all of the manufactured materials employed in the construction of roads. There is hardly a street or highway of any kind built in which cement is not used, either in the base of surface course of the pavement or in the construction of drainage structures, curbs, etc. The present requirements of the Bureau of Public Roads specify that all cement used in Federal Aid construction must be tested regardless of the amount involved. Practically all portland cement is now manufactured under the specifications and is tested by the methods prescribed by the American Society for Testing Materials. Several years' experience in testing this material has convinced the writer that although these methods of tests are far from perfect they are sufficiently accurate when properly conducted to detect inferior cement. The words "properly conducted" are used advisedly because there are many laboratories which are unfortunately carrying on routine tests of cement in an incorrect manner. Throughout this paper, however, it will be assumed that the laboratory methods in use conform to the best practice, and that what variations in results are obtained are due rather to inaccuracies in the test itself than to carelessness or ignorance on the part of the laboratory. The present specification limits for portland cement have been set so low, particularly as regards tensile strength, that there should be no difficulty for any standard brand properly manufactured to meet the requirements. For this reason, the writer would be inclined to adhere rigidly to the present American Society for Testing Materials' requirements, except possibly in the case of the fineness test where a 1 per cent tolerance is permissible to cover unavoidable variations in testing.

In this connection it is well in interpreting fineness test results to be sure that a standardized cement sieve was used. Cement No. 200-mesh sieves now on the market are apt to vary as much as 3 per cent from the true value. All reports of fineness tests should indicate that the result has been corrected and should give the correction factor. The U. S. Bureau of Standards will standardize cement sieves for a nominal charge. Results of tests for time of set are usually well within specification limits. Due to the large personal equation involved in this test, no significance should be attached to variations within the limits. About the only value the test has is to detect a flash set. If a flash is reported, however, the cement should positively not be used until it has been thoroughly re-tested and found to be O.K. A word also about the soundness test may not be amiss. A mere report of unsoundness by the laboratory is not sufficient cause for rejection. Unsoundness is caused by the hydration of an excess of free lime which produces disintegration in the cement by reason of its increase in volume. If a cement showing such unsoundness is stored for a period of two or three weeks prior to use, the chances are that the lime will air slake and thus become inert. Cements therefore which are unsound when first tested should always be held for a sufficient period to allow this slaking to occur, after which they should be re-tested and if sound, accepted for use.

The strength and durability of concrete depends fully as much on the character of the aggregates used as on the quality of cement. For this reason a number of tests have been devised and requirements established for both fine and coarse aggregates for the various types of construction.

Fine Aggregates.—Fine aggregates, that is, sand, stone screenings, or combinations thereof, are usually subjected in the laboratory to four routine tests: grading or mechanical analysis, silt content, mortar strength, and color test for organic impurities. This is, of course, in addition to tests on the concrete fabricated from the aggregates being investigated. A discussion of the significance of these laboratory tests as they apply to the use of sand for concrete road construction will serve to call attention to some points which are not always appreciated by engineers. The grading of the concrete sand is an important consideration apart from any other test. If the sand is too fine, a weak mortar and a low resistance to wear will be produced. If, on the other hand, it is too coarse, a harsh open mix difficult to work and with a consequent tendency towards the use of too much water will result. The average specification for sand controls the grading within safe limits. The trouble has been that many engineers look upon the test for mechanical analysis as secondary to the strength test and are inclined to waive the former if the strength be within the specification requirement. A knowledge of the relations existing between the various tests would show that many sands much too coarse for satisfactory use in concrete will show very high strength ratios. Results of the strength test under these conditions are very misleading, because of the natural assumption that the higher the strength the better the sand. The point to be emphasized here is that the strength test should only be considered in conjunction with the grading. If this is done, the strength of the sand for any given grading will be an indication of its quality. Thus, for a normally graded concrete sand; that is, one showing about 20 per cent coarser than a No. 20 sieve, a strength ratio of 100 per cent, indicates satisfactory quality. A lower strength is an indication either of the presence of some deleterious substances such as organic matter or that the sand grains are of poor quality. An unusually high strength invariably indicates a very coarsely graded sand. The color test for organic impurities alone is only an indication of danger because there are substances found in concrete sands such as lignite, small particles of coal, etc., which show an unfavorable reaction and are still entirely harmless. If, however, the sand when normally graded shows low strength, the chances are that the substances causing the color are of a harmful nature. If, on the other hand, the normally graded sample shows a low strength and no organic impurities, the trouble is undoubtedly due to poor quality of grains. Tests for silt content are usually positive indications, especially if the determination has been made by weight. Presence of silt in any sand which is to be used in a concrete surface exposed to wear is of course undesirable for this fine material tends to work to the surface and greatly weaken it. The usual specification allows a limit of 3 per cent, and in concrete road construction it is seldom wise to exceed this limit. The term "silt" in this connection is used to cover only the material lost in the elutriation or washing test. It is usually composed of clay, loam or excessively fine sand, considerably finer that a No. 200 sieve. Ordinary fine sand passing a 100-mesh sieve is not harmful in amounts less than 10 per cent providing the silt content is low.

Coarse Aggregates.—Stone, gravel or slag which is to be used in the construction of concrete pavements should, in addition to being structurally sound, possess sufficient resistance to wear to withstand the abrasive action of traffic. This is particularly true in the case of city streets which are subjected to an appreciable steel-tired traffic. The most commonly applied test for coarse aggregates is the Deval abrasion test. It was designed originally for use in testing macadam stone. The need for some form of test for quality of coarse aggregate led to its adoption for this purpose in spite of the fact that there are many engineers who believe that it is wrong in principle when used in this connection. The test can be applied either to stone, slag, or gravel. The methods of testing, however, are somewhat different so that the results are not directly comparable. Opinion differs as to the proper test limits to apply when selecting aggregates for pavements. Many concrete roads constructed of stone with a percentage of wear as high as 6.5 or even 7.0 have given good service. As in the case of other materials, however, the best available aggregate should be used and it is for the purpose of comparing available materials that this is of particular value. Although as stated above there is no direct relation between the results of abrasion tests of stone, gravel and slag, numerous laboratory tests have shown that, in general, these materials when of approximately equal quality, will show results in the ratio of about 1:3:2. That is, gravel with a percentage of wear of 15 and slag with a percentage of wear of 10 will be of approximately the same quality as stone with a percentage of wear of 5. It will be observed that no reference is here made to the French coefficient of wear. Testing engineers are now practically unanimously in favor of abandoning this term. It really has no added significance, being merely the quotient obtained by dividing the constant 40 by the percentage of wear. It is rather difficult to discontinue the use of the term, however, because almost all highway engineers are accustomed to think only in terms of coefficients. With regard to tolerances which should be allowed when interpreting this test, it is probable that, in general, the test is not accurate to less than 0.5 per cent for stone or 1 per cent for slag or gravel, the difference being due to the fact that stone is usually more uniform than either of the other aggregates. Such a liberal tolerance is made necessary simply because the test can not be depended upon to give results with any greater degree of accuracy. Many attempts have been made to improve the method, but so far none of them has been adopted as standard.

Although stone may be tested for hardness, toughness, etc., in addition to the abrasion test, the writer believes that the latter is sufficient control when the material is to be used for concrete aggregate. In the case of stone to be used in the construction of bituminous macadam or bituminous concrete roads, however, the toughness test has been found to be of value. In the case of gravel, uniformity of quality is the most essential requirement. This means freedom from soft, disintegrated fragments and an impact test has been developed for* determining the percentage of such fragments in a gravel sample. Sufficient data has not as yet been accumulated to permit setting any test limits. For slag, density is the chief requisite. To determine this, a test for weight per cubic foot of crushed slag is made. The usual requirements specify a weight of 75 lbs. per cubic foot for pavements. Many good slag concrete roads have been built, however, with slag running as low as 70 lbs. to the foot. It would seem, however, that this is about as low as one should go until further information regarding the use of light slag in pavements is available. The Bureau of Public Roads has constructed and is now testing an experimental concrete pavement in which a large number of samples of stone, gravel and slag of widely varying characteristics are used. The results of this test should throw considerable light on this important question.

Grading of Coarse Aggregates.—The proper grading or size of coarse aggregate will depend on the type of construction. Practice as regards concrete pavements varies in different parts of the country, a maximum size of 2¾ in. being allowed in many of the eastern states. The chances are that the maximum size is not an extremely important factor provided the aggregate is well graded from coarse to fine. A sample showing anywhere from 50 to 75 per cent retained on a screen intermediate in size between the largest and the smallest may be said to be satisfactorily graded. The maximum size of 2 in., which is allowed in Pennsylvania, New Jersey, etc., is largely due to the added cost of further crushing the very hard and tough trap rock quarried in this section. Experience so far seems to indicate that the large stone is satisfactory.

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*A. S. T. M. Proc., 1922, "An Impact Test for Gravel," by F. H. Jackson. See also Engineering and Contracting, Aug. 2, 1922.

In applying tolerances in connection with results of grading tests, it has been the custom in the past to allow a variation not to exceed 5 per cent larger than the maximum size or smaller than the minimum size, which is usually ¼ in. This is all right in theory but does not work out very well in practice because, as is well known, stone, in general, retained on a ¼-in. revolving plant screen will often contain as much as 15 per cent passing a laboratory screen of the same size. Likewise, the efficient working of some gravel pits require that the coarse aggregate carry considerable "tolerance" material. Purdue University recently conducted a series of tests to determine to what extent the so-called "tolerance" material was harmful, resulting in the conclusion that as high as 15 per cent might be allowed without seriously affecting the strength of the concrete.[†] The principal consideration affecting control tests for grading of aggregates is that the material run fairly uniform from day to day. This is usually determined by testing with a set of field screens right on the job or at the producing plant. One additional point in connection with screen analyses of aggregates should be mentioned. Some specifications call for the material to be the product of the crusher passing a revolving screen with openings of a certain size, say, 3 in., and to be retained on a revolving screen with openings of a certain size, say, 1 in. Everyone who has had experience with crushing plant practice will realize how uncertain such a specification is. There are so many factors which influence the size of a stone product, such as the speed and angle of the screen, amount of moisture on the stone, etc., that the only safe plan is to specify that samples of the products be of definite size as determined by laboratory screens. Knowing these requirements, the quarry man can adust his equipment so that they can be complied with. It will be found that this is a much safer plan than to be compelled to accept aggregates simply because they were produced in a plant having screens of certain specified size.

Stone for Macadam.—Turning now to stone to be used in macadam construction, we find not only the abrasion test but the toughness test and sometimes the hardness test used in examining the material. In a macadam road, the stone being held in place by a more or less non-rigid binder is not supported on all sides to the same extent as the coarse aggregate in concrete. For this reason there is more chance for the individual fragments to wear in the macadam type and consequently a greater necessity for a tough, durable stone, especially under heavy traffic. The engineer is justified, therefore, in taking only the best available stone and the laboratory may often be of considerable assistance to him in making his selection. Good practice does not in general recommend the use of stone for bituminous macadam where the per cent of wear is more than 5.5. The toughness likewise should be at least 6.0. For mixed bituminous concrete, a per cent of wear of not more than 5.0 and a toughness of at least 8 is usually required. The type of stone should also be taken into consideration. Many engineers specify a lower percentage of wear for trap or granite than for limestone for a given construction. This is done because the trap and granite are naturally much harder than the limestone, so that a trap showing a percentage of wear greater than normal is likely to be disintegrated or otherwise to be of inferior quality to the limestone even though the actual wear as shown by the test is the same. Type is also an important consideration if water-bound or plain macadam construction is used. It is well known that certain types, such as the quartzite, gneiss, schists, etc., will not bond on the road and for this reason they should not be used in the wearing course. Simple determination of type of road is all that is necessary in this case, which is partly the reason why the so-called "cementation test" for rock is not now used to any great extent.

Gravel for Surfacing.—The testing of gravels for road surfacing is confined largely to a washing test to determine the percentage of clay present and a mechanical analysis to determine the grading of the sand and gravel from the maximum size down to dust, with the gravel fraction weighing about two-thirds of the total. Just enough clay should be present to act as a binder. The amount of clay to be allowed will depend on the character of the gravel, ranging from as little as possible in some limestone gravels to as high as 10 to 15 per cent by weight in pure quartz gravels. The maximum size will vary with condition, but as a rule should not be placed at more than two-thirds the depth of the course when the gravel is to be used as a base and not more than 1½ in. for topping. The tendency recently has been for smaller gravel in the top. In order to control the quality of gravel for wearing course, an abrasion course is sometimes specified. Although when two or more available deposits are under consideration it is certainly advisable to take the one in which the best grade of stone occurs, it is not usually economically justifiable to reject local in favor of imported material simply on the score of an abrasion test. For this reason the writer would be inclined to waive this requirement under ordinary conditions provided the material was otherwise satisfactory. Due to the wide range in grading of the average gravel pit, it is essential that rather liberal tolerances be allowed if the road is to be built. For instance it is hardly practical to reject pit run material which varies from 50 to 75 per cent retained on the ¼-in. screen. It is simply impossible in the case of most pits to secure material which will run any more uniform than this. Again, if a specification calls for a 10 per cent clay content, some tolerance, say, 5 per cent, may be allowed. It is seldom wise to allow a clay content in any case in excess of 20 per cent.

Paving Brick.—About the only test to which vitrified paving brick is now subjected is the standard rattler test. This test has been used a great many years and has given, in general, entire satisfaction, although the writer believes that it, in common with many other tests, can be improved. About the only point to which attention should be called here is the effect of size and type of brick on the rattler loss. It is known that re-pressed brick will lose slightly less than wire cut brick of equal quality due to rounded edges of the former. Likewise, 3-in. brick will show a somewhat greater percentage of wear than 4-in. brick of equal quality due to the greater number of linear inches of edges in proportion to weight which are exposed to wear. In the absence of specific data, one would probably be safe in allowing a 1-in. differential in favor of the wire cut type over the re-pressed and a 1 to 2 per cent differential for a 3-in. over a 4-in. brick.

Stone Block.—Considerable trouble has in the past been experienced in the testing of stone block chiefly because of the attempt to apply the macadam stone tests to this material. The writer has discussed this point a number of times[*] and it will not be necessary to go into details in this paper. Suffice it to say that the Deval abrasion test is not accurate enough to differentiate between the various grades of granite block on the market except in a very rough way. In other words, in using this test, no attention should be paid to a few tenths of a per cent variation. The test will indicate the presence of soft, inferior stone and this is about as far as it can be depended upon.

Conclusion.—In a paper of this length, it is of course impossible to go very much into the details of this important subject. It is hoped, however, that enough has been covered to indicate the major points to be considered. The object of the paper is to show the necessity of taking certain things into consideration when interpreting test data and when setting specification limits for materials. The fact that these things are not always considered is, the writer believes, the principal reason for much impractical interpretation of laboratory results. It is largely a question of mutual misunderstanding, and the writer sincerely hopes that this paper will contribute at least slightly towards clearing up some of the doubtful points.

[†] "Permissible Tolerance of Sand in Coarse Aggregates," by W. K. Hatt, Director, Highway Research Committee, Division of Engineering, National Research Council.

[*] "Laboratory Tests of Granite Paving Block and Suggested Specifications," by F. H. Jackson, Engineering and Contracting, March 3, 1920.

Over 1,000,000 Motor Trucks in U. S. in 1921.—In 1913 there were 64,000 motor trucks registered in this country; in 1914 there were 85,000; in 1915 140,000; in 1916 198,000; in 1917 289,000; in 1918 433,000; in 1919 749,000; in 1920 975,000; and in 1921 1,050,000. Passenger car registration increased from 1917 to 1921, a total of 96 per cent, while during the same year truck registration grew from a small total to an increase of 263 per cent as compared with the automobiles.

Gravel Road Construction in Montana

The following interesting account of the development of gravel surface highways in Montana is reprinted from the Montana Highway News, the official publication of the State Highway Department.

Not so very long ago gravel roads in Montana were built of bank run material, excluding only those particles larger than about 3 ins. in size. This type of road was not altogether unsatisfactory for horse drawn traffic, but as the surface material gradually wore away the large pieces of gravel were exposed forming a rough and uneven surface objectionable and uncomfortable for automobile traffic. Moreover the action of the driving wheels of the automobile upon the gravel surface accelerated the removal of that cushion of sand or other fine particles; and the result was an increased deterioration of the surface. In 1920 the highway department and several of the counties of the state adopted a specification for gravel roads which limited the maximum size of gravel to 1½ ins. This surface represented a decided improvement, although failure to make use of the larger particles of gravel in the pit constituted a serious waste and materially reduced the output of usable material.

The next progressive step was the requirement that the gravel larger than 1½ in. in size should be passed through the crusher and this crushed product used in the road surface. Finally in 1921 the specification now used by the department was adopted. Briefly this specification requires that all gravel in the pit up to approximately 4 in. in size and excepting the sand shall be passed through one or more crushers; of the crushed product only that which has passed the 1¼ in. opening of a circular revolving screen may be used in the road surface; and the material must be placed on the road in two courses, each to be spread and compacted separately.

It is, of course, necessary to control the percentage of sand and crusher dust or other fine particles that are used in the road surface. However, experience indicates that a much larger percentage of fine material can be used than that which was formerly thought possible; so that a crushed gravel material that will form a thoroughly satisfactory road surface, when inspected visually seems to contain too much fine material and too little coarse aggregate.

The usual thickness for crushed gravel surface is 7 in. measured before compaction, although the thickness is varied to meet the subgrade conditions. Not infrequently it is found desirable to resurface an old pit run gravel road under which circumstances a minimum thickness of 4 or preferably 5 in. is permitted. Whenever the conditions seem to require a thickness of gravel greater than 7 in., the top course or wearing surface may be 5 in. thick of crushed material passing a 1¼ in. screen and the foundation course is placed as thick as judgment dictates, using material up to 2 or 2½ in. in size. The ideal gravel surface would be built exactly as just indicated, that is, with a foundation course of relatively large material and a wearing course not less than 5 in. thick of the smaller crushed particles.

The type of gravel surface now being used by the department lends itself to economical and efficient maintenance because there is no particle of gravel within at least 5 in. of the surface of the road that is too large to be on the surface. Regardless of their continuous maintenance by means of blade graders there will come a time when all of our gravel roads need to be broken up and reshaped by scarifying and reshaping; and if large stones are used within 5 in. of the top they are certain to be brought to the surface by the teeth of the scarifier, there to cause inconvenience to travel or to cause extra expense for removal. When the Commission lets contracts for the construction of a gravel road surface, it also contracts for the crushing and stock piling of maintenance gravel. This maintenance gravel is required to pass a 1-in. screen opening and is stored along the road in piles about ¼ mile apart, using 50 cu. yd. per mile of road. The maintenance of gravel roads by the Commission during the present season will probably not exceed $150 per mile.

The decided improvement in the type of gravel surface has not been paralleled with an increased cost. The department is today paying less for crushed material conforming to the higher standard specifications than it paid early in 1920 for pit run material. The average price per cubic yard for gravel surfacing in 1920 was $3.00 as against $2.62 for 1921 and $2.40 for 1923. The cost per mile of the gravel surfacing only at the average unit price of $2.40 using the quantities of gravel sections recently developed by the highway department is as follows: For 12-ft gravel sections $2,541 to $3,285; for 15-ft. gravel sections, $3,502 to $4,106; for 18-ft. gravel sections, $4,262 to $4,927.

In connection with the reservation road projects which the Commission is now initiating it is proposed to introduce two other types of gravel surface both new to the state. In one of these the base course will be composed of material passing a 1½ in. screen while the top course will contain only material passing the 1-in. screen. The other type will require approximately 6 in. of crushed gravel passing the 1¼ in. screen opening as at present specified by the department, but will also provide for the addition of a top course approximately 1½ in. in thickness composed of material passing a ⅝ in. screen. Bureau of Public Roads' officials agree with the Commission that a comparison of these two types with that now used as standard in the state will be interesting and instructive.

Lights for Motor and Horse Drawn Vehicles

Essential Factors in Highway Safety Such as Road Lighting Systems and Day and Night Road Signals, Discussed in Paper Presented Nov. 21 at Joint Sessions of North Central Division of National Highway Traffic Association and Michigan State Good Roads Association.

By DAVID BEECROFT.

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National Highway Traffic Association.

Much has been done with our highways to make them safer. Much has been done with vehicular lighting but much yet remains to be accomplished. Painting the center line of horizontal and vertical curves has already accomplished admirable results. A lamentable lack of standardization still exists in the marking of "steep hills," "dangerous curves" and "dangerous highway intersections," etc. Our highway signals are too frequently obscured if not often completely hidden by business road signs that are too often placed on curves and at other dangerous points, where all such should be legislated against and only the use of highway marking signs permitted.

The author of this paper was asked to give special considerations to the question of motor trucks and with this thought in mind communicated with various states on this particular subject and the varying character of replies indicated that no comprehensive study and classifications of accidents have been entered upon by many states—a work that would seem highly necessary if a complete interpretation is to be arrived at.

The Present Situation in Various States.—We are having accidents with cars and vehicles of all classes. There is no general agreement as to the cause of these accidents. In Michigan Charles J. DeLand, secretary of state, says that accidents are occurring continually on the highways of the state due to improper equipment of both motor trucks and passenger cars. Secretary DeLand goes on to state that no other law in the statute books of Michigan is more openly violated than that regulating lights on motor vehicles of all descriptions. He makes no mention of lights on horse drawn vehicles or the absence of them. That is a factor in the catagory of accidents. However, he continues: Trucks are being operated on the highways with a searchlight on the cab which is like a blinding headlight to persons approaching in the opposite direction and these same trucks very often have a big trailer with no light of any description on the rear to say nothing of the width of the body. My suggestion is some drastic legislation that will compel owners and drivers of trucks to equip same with two white lights on front than can be turned on the road and with a red or green light on each side of the truck on the rear.

So much for the views from Michigan. New York state has a different report. Bert Lord, the director of motor vehicle bureau of the state of New York says: "I have no information on file as to accidents. However, I am aware there have been a number of accidents due to wide trucks, and on account of it a bill was introduced requiring a green light on the outer left hand corner of the truck so that motorists could know the width of the truck when approaching it. The measure did not become a law and I do not think I would approve the green light. However, a white light possibly would be good."

I am glad to see Mr. Lord opposed to green light for reasons to be given later.

The state of Maryland has a system of highways used a great deal by motor trucks but D. Marshall Schroeder, deputy commissioner of motor vehicles, cannot recall any accidents due to the width of motor trucks. His office does not classify accidents or collisions between different types of motor vehicles.

Mr. Schroeder continues: "I do believe that it is an excellent plan to suggest that all motor vehicles carry a light similar to a parking light on the extreme left showing white in front and red to the rear.

Causes of Accidents in Connecticut.—The state commissioner of Connecticut has gone further than any other state in a study of accidents and for two years has investigated every accident occurring on the highways of the state and has classified these accidents showing the number to which the blame is due to motor cars, motor trucks, motorcycles, trolley cars, horse vehicles, railroads, pedestrians, etc. This analysis for 1921 shows that approximately 91 per cent of all accidents on the highways can be eliminated by highway improvement, better highway lighting, improved signals, better lighting of motor vehicles, improved regulation of all vehicles and general education of those using the highways. The commissioner of motor vehicles believes that only 7 per cent of all highway accidents cannot be avoided. Because of the study that has been given to this subject in Connecticut we should hear carefully what the commissioner of motor vehicles has to say. He exhibits that great qualification of meekness, admitting that the more he has studied the subject, the less is he willing to attempt to settle the entire question by regulating lights on different classes of vehicles. He says: "I need to be convinced that accidents happen on account of the abscence of some light which will indicate the character of the vehicle and while I have not our statistics on this point yet, off hand, I am doubtful as to whether they will bear out the suggestion that has been made to the effect that lack of lights indicating truck width is a fruitful cause of accidents."

These words from Robbins D. Stoeckel, commissioner of motor vehicles for the state of Connecticut are deserving of careful consideration as this state is crossed by the highways between New York City and Boston, in fact by the highways between New York City and the greater part of New England. These highways have heavy motor truck traffic perhaps as heavy as any other state in the union.

In the Commonwealth of Massachusetts the green light on the extreme left side of the truck is favored. It is considered a convenience as well as a factor of safety.

The state of Delaware reports several accidents due to lights on motor trucks.

Pennsylvania has no record of any special accidents caused by motorists not being familiar with the widths of motor trucks.

Minnesota has had very few accidents due to the width of trucks and has no regulations calling for lights to indicate truck width, but Secretary of State Mike Holm adds," We have had very few accidents due to truck width."

Time will not permit further comment on the experience of the different states but in no others can evidence be secured that width of truck has been a special factor in accidents. After reading the opinions of motor vehicle commissioners, in half a dozen states, that now have heavy motor truck travel, only one conclusion can be reached, viz: That perhaps with the single exception of Connecticut no adequate analysis of accidents has been made to establish any relationship between lighting of vehicles and the accidents.

Perhaps up to the present we represent the consensus of opinion by stating that motor cars are too often overlighted and motor trucks generally underlighted. We rarely meet the motor truck with its dazzling headlight, but too frequently we meet the inefficient pair of oil lights on the truck that are not adequate and are in reality useless except as signal lights.

Conditions on Day and Night Highways.—Let us now briefly consider the highways on which these vehicles operate day and night. Some of these roadways have become virtually high roads for commodity and passenger transport, similar to our railroad lines. They have quite entirely outgrown the use made of them a few years ago, yet notwithstanding this transition they are not lighted in any sense commensurate with the travel on them. Perhaps the road surface has been improved, but more equipment is needed along these high roads of commerce than merely a surface. Why should we not take a chapter from railroad transportation, trolley transportation, marine transportation and equip these highways as the traffic over them demands; in other words, after building a permanent surface roadway, complete the job by getting it ready for use, not merely in daylight hours, but during many hours of the night as the need of the times demand. Again may we repeat: Let us finish the job and realize that when we have built a 15 foot concrete highway we have not finished the job. A railroad is not completed when the roadbed is done and the track laid. The signals for the day and night travel are as essential as the steel rails. Our riverways and canals are not completed when the adequate depth of channel is achieved, the signals for day and lights for night must be installed. What an intricate signal system has been developed along our coast for coastwise and high sea travel. What a system of lights and signals has had to be established for the air service between London and Paris as well as other air routes.

In this reference to railroad, marine and aerial lighting along their respective ways of travel, there has been no thought of diverting attention from adequate lights on all users of our roads, but rather the thought has been to survey broadly all factors entering into safety of our highways and not to be guilty of approaching the subject from a single and selfish viewpoint.

Elimination of accidents will not be achieved by attacking at one point, but rather by correlated attacks at all points where attention is needed. Connecticut has shown that where an accident a day occurred on a part of the highway, further accidents were practically eliminated by relocating a short portion of the highway and removing bordering interferences. The old location was safe for horse traffic and for years fairly safe for motor traffic but with the present multiplication of traffic the only solution of accidents lay in relocating the offending portion of the highway.

Our cities have done excellent work by improved traffic control, by establishing safety zones for pedestrians, by an attempted control of pedestrians, by surface markings on streets, by suitable night signals, etc. This commendable work prompts us to ask the question if our state departments having control of our highways have sufficiently realized that some of this work needed in making our cities and towns safe, should be extended to the rural highways, particularly those portions constituting main arteries with heavy travel day and part of the night.

Highway Lighting.—Before leaving this study of the highway let us consider briefly the subject of highway lighting. It is only in the last few years that this subject has been given anything resembling serious consideration by concerns that have developed systems for city lighting. The A. B. C. of highway lighting has yet to be written. A few stretches of highway are being lighted with experimental systems, that give promise of excellent results and our state departments must keep this subject in mind as a part of the problems of making our highways safe and constitute a part of the task of highway regulation.

Lights on the Vehicle.—Coming to the consideration of the lights to be carried by all vehicles using the highway, I aim to be sanely conservative by emphasizing that the time has arrived when vehicles of all characters must be equipped with a lighting system standardized so far as color and position of lights are concerned. We cannot temporize longer with the horse vehicle that is a double danger, first to itself and second to the other users of the highway. We cannot temporize further with the motor truck that hangs a lantern with a red glass from the center of the body at the rear. We cannot temporize further with the reaction engine pulling a threshing machine and water wagon with not a rear signal light, and too frequently a single lantern with white glass on the front. We cannot temporize further with the motor car that offends with its dazzling headlight. Our highways at night are no longer used for a few miles by residents along the route, but nightly our interstate roadways used by vehicles whose owners may reside in the adjoining state or several states beyond. Nightly these highways are used by those who are often strangers to them, not infrequently by many who may not use them again for years. This character of travel makes it correspondingly more important that all users observe the lighting laws. In writing regulations governing lights, there must be no favoritism for any particular type of vehicles, all must be considered as users of the highway and equally subject to regulations governing their use.

The Color of the Tail Light.—Considering the specific lights used perhaps no one light has been more widely discussed during the past year than that of the color of the tail light. About one year ago a movement was started, backed partly by railroad interests, to have the use of the red tail light on motor vehicles discontinued and a yellow light substituted. The reasons advanced were that where roadways paralleled railroad lines, locomotive engineers were at times confused in their signals. Fortunately we feel certain, there has been a change of heart and now the railroads are resigned to the use of the red tail light on motor vehicles and everybody else from scientists down, are of the opinion that no better rear signal exists than the red light. Its future use is undoubtedly assured. It should be the universal light for the rear of all highway vehicles, motor propelled, horse drawn or propelled by persons. Such a standardization of its use will simplify night driving, will conserve the mental energy of the operators of all types of vehicles and should be conducive to better physical control of vehicles with a corresponding lowering of accidents.

Granting that the red tail light is to be the permanent light its location is yet open to debate and also the capacity of the light to adequately illumine the state registration numerals. The Commonwealth of Massachusetts has recently attacked this problem with vigor and the new law requires the lamp portion to be above the middle of the license bracket and to throw a white light over the face of the numerals. This light must be thrown through a glass portion of the lamp and not through mica or celluloid window. No objection can be urged against what Massachusetts has done. She is merely carrying out the intent of the original law in many states covering the illumination of lighting bracket. The new law is a just one.

The Location of the Tail Light.—The location of the tail light is far from being a settled question, particularly on motor trucks, threshing machines, trailers, etc. The extreme left rear of the body is considered generally the most useful location in that it designates the extreme edge of the body and so serves as a valuable guide to overtaking vehicles that must pass on the left. This location should avoid those accidents due to no indication of the body width when the light is under the center of the chassis. Carrying a swinging lantern with a red glass under the middle of the rear end of a vehicle is not sufficient. A red light at the extreme left should be carried on all types of horse vehicles, motor vehicles, trailers and machinery in tow such as threshing machines, etc. There is no necessity for two red lights on the rear of any vehicle. It has been suggested that on large trucks there should be one at each side of the body, some states going so far as to suggest a red light at one side and a green light at the other. Two lights merely double the number the drivers in following vehicles have to see. They will confuse rather than clarify. Our lighting of vehicles and roadways must be simplified to the final syllable and it is the golden rule of vehicular lighting not to use two lights where the job can be done better with one. This may be opposed to the business adage of making two blades of grass grow where one grew formerly, but the case is different. Let the rule be to let one sufficie if it does the job. Further there should be no necessity for specially large tail lights on motor trucks, a standard size will suffice if properly located and with an adequate electric bulb to illuminate.

Still another thought with regard to the tail light: If it is to be placed on the extreme left rear of the body it can play the dual role of showing a red light to the rear and a white light ahead, thus indicating the approaching vehicle, the extreme width of the vehicle body.

This brings us to the question of the use of a light showing forward that will indicate to approaching vehicles that the vehicle is a motor truck as well as indicating the extreme left side of the vehicle. You will recall that the use of such a light is much disputed by the motor vehicle commissioners in different states. The author of this paper is open minded as to the use of such a light, but has definite opinions concerning its color. Only a white light should be used. A green light has been suggested, but it will add to the confusion of drivers of approaching vehicles, particularly at the present when green lights are used on highways for so many other purposes. We repeat that good lighting on vehicles should be simplified rather than made more intricate.

Professor Blanchard has suggested a white light located centrally above the dash on cab to designate the character of the vehicle approaching.

The alphabet of color is red for danger—stop. White stands for forward illumination and signals. These are enough for the vehicle. But the universal alphabet of green be for caution, and its use confined to the role of highway signals.

R. F. D. Road Dragging Associations.

An interesting plan for securing the dragging of the unclassified rural routes is employed in Jackson county, Missouri. Under this plan the county court pays half the cost and the people along the route pay the other half. The county appropriation is limited to $10 per mile. We are indebted to the last annual report of J. W. Wilson, County Highway Engineer, for the following details:

To get county aid for dragging, the patrons along a rural route must organize by selecting a board to manage their business and elect a president and a secretary-treasurer. In some cases the rural carrier is elected to serve as secretary-treasurer. These officers, together with the rural carrier, constitute the executive committee. They raise their money, deposit it in any bank in the name of their association and pay the men who do the dragging out of this fund, using a voucher book furnished for that purpose. They select the men to do the dragging, make changes, fill vacancies, decide what they will pay for dragging and have complete charge of their business. Both the money they raise and the money the county sends them is their money and it is their roads.

As soon as they organize they are required to make a report to the county highway engineer, giving date of organization, the number of the route, the names of the officers and members of the board and the names of those who have donated to their dragging fund and the amount each agreed to contribute. About five or six months after organization (or as soon as the county money is needed) they are required to submit another report signed by the rural carrier, the president, secretary-treasurer and board members certifying that they have been keeping their roads dragged and giving the names of those who have contributed to the drag fund and the actual amount of cash collected. If this report is satisfactory, the county court agrees to send to the secretary-treasurer of the drag association a voucher on the county treasurer for a sum equal to the amount the association has collected, provided the total contribution by the county does not exceed $10 per mile. The secretary-treasurer deposits this voucher in his bank in the name of his association with the remainder of their money and continues to draw on it the same as during the first half of the year.

The association may include the spur, or side roads over which the carrier does not pass, if they decide to do so. The association may include any county special grade over which the carrier travels, provided the association raises its part of the money along these roads the same as the other roads. When county special grades are thus included, the county does not pay an additional $10 per mile, but will pay the same $10 per mile into the drag association fund instead of throwing it into the road district fund.

The patrons of a route may meet at some central school house and organize, or the rural carrier may consult with his patrons and recommend to the highway engineer a board of directors to start the organization. On the average route an average of $4 or $5 per box will raise the full amount of $10 per mile.

A third report is required from each association about the first of February to complete the records in the office of the County Highway Engineer.

An association must actually keep its roads dragged or it cannot get aid from the county. If it places its money in the bank and fails to drag its roads we will not match their money.

Safety First for Pedestrians.

From The Service Bulletin of the Iowa State Highway Commission.

Pedestrians making use of the highways should always walk facing the oncoming traffic. It is a common custom for people walking on the highway to walk on the right hand side of the road going in the direction of the traffic. With so many cars on the highways running at the present time with poor lights or no lights at all this is an extremely dangerous situation. It will save many accidents and escapes from accidents if people who use the highways for foot travel will reverse the ordinary custom and walk in such manner as to face the oncoming cars. New Jersey is reported to be considering a law which will require that a foot path of some kind be built along the side of each important highway.

Fire Prevention in Highway Bridges

Important Factors Governing the Fire Hazard in Timber Bridge Construction

During the past few years a number of serious fires have occurred on important bridges. The circumstances attending these fires have indicated the desirability of making a detailed study of the situation. Accordingly a co-operative committee was formed, representing fire protection, highway bridge construction, lumber, creosoting and the public interest. The committee consisted of Chairman, Geo. W. Booth, Chief Engineer, National Board of Fire Underwriters; L. T. Ericson, Chief Engineer, The Jennison-Wright Co.; C. M. Taylor, Past President, American Wood Preserver's Association; D. F. Holtman, Construction Engineer, National Lumber Manufacturers' Association; C. J. Hogue, Manager, West Coast Forest Products Bureau; F. E. Schmitt, Associate Editor, Engineering News-Record; Secretary, E. F. Kelley, Senior Highway Bridge Engineer, U. S. Bureau of Public Roads.

An extensive correspondence was carried on, with city, county and state bridge engineers, and with the information thus obtained, and information collected from other sources as a basis, the committee submitted a report, which was made public on Nov. 1. The report follows:

Fire Risk.—The existence of a fire risk in bridges having wooden floors must be recognized. An indication of the importance of this risk is the fact that on some heavily traveled city bridges small fires are of daily occurrence during the summer months.*

The available evidence indicates that this risk is much less for country bridges that for city bridges and is greater on long bridges than on short ones.

Causes of Fires.—On city bridges, fires are most commonly caused by the lodgment of lighted cigar or cigarette stubs in cracks or depressions where chaff and debris have collected. Decayed or splintered material in the floor adds greatly to the fire risk. In the case of country bridges the greatest risk is from forest and grass fires.

Other reported causes of fires are:

Sparks from locomotives or steamboats.

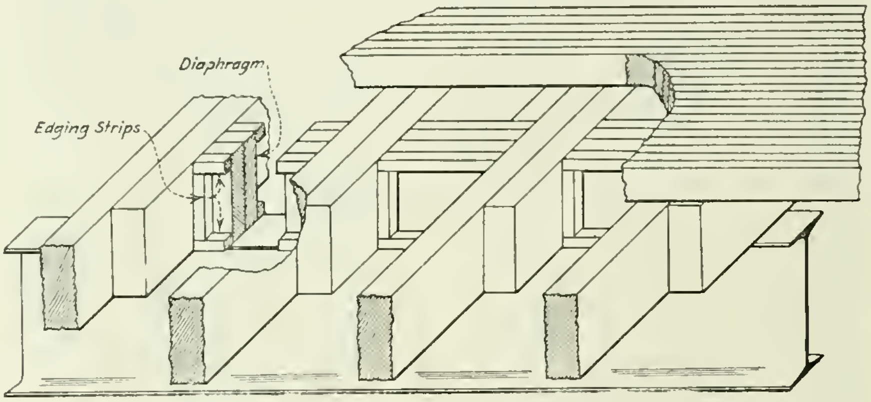
Hot coals dropped by steam rollers, traction engines, tar kettles or other construction equipment.

Burning waste dropped by street cars.

Defective insulation of electric wiring; defective bonding of rails and lack of capacity in return feed wires of electric railways.

Fires in adjacent structures.

Relation of Preservative Treatment to Fire Risk.—Creosoted material appears to be somewhat more difficult to ignite than untreated material, but once ignited it creates a fire which is hotter and more difficult to control and which is known by experience to be more destructive than fire in an untreated floor. However, decayed or partially decayed untreated wood is very easily ignited and has been the cause of many fires. The likelihood of fire is increased by treatment which results in excessive bleeding of oil, such as might be caused by the heavy treatment of green lumber. It should be noted that freshly creosoted material is much more inflammable than that in which the treatment is several months old. It is urgently recommended that orders for creosoted material be placed as far as possible in advance of construction and that the material be seasoned for from three to six months after treatment.



Recommended Construction for Fire Stop Diaphragm Over Floor Beams.

Where it is practicable to do so, freshly treated timber may be rendered more fire resistant by thoroughly coating the upper surface with sand. The application of sand should be continued as long as there is any bleeding of oil.

Construction.—In general it may be stated that tightly laid floors, in which cracks are eliminated to a large extent, are most fire resistant.†

The relative fire risk of various types of floor may be stated as follows, beginning with the most fire resistive:

Wood blocks on concrete base. This type of floor may be said to have no fire risk.

Wood blocks on plank subfloor.

Laminated floor of 4-in., 6-in. or 8-in. strips laid on edge and spiked together, with a bituminous wearing surface.

Plank floor with bituminous wearing surface.

Laminated floor without wearing surface.

Multiple thickness plank floor.

Single thickness plank floor.

Steel joists or stringers supporting floors of any of the above types reduce the risk of rapid spread of fire by reducing the amount of combustible material exposed. Where wood joists or stringers are used the fire risk will be reduced by using heavy timbers for these members. The massing of combustible material renders it less susceptible to ignition and the spread of fire and lessens the probability of serious structural damage before the fire can be controlled, in case fire fighting means are at hand.

Special care should be exercised in the design of the floor and its supporting structure to avoid ledges or pockets in which trash may collect. The possibility of the accumulation of rubbish on truss members and in floor openings made for the passage of these members should be given careful consideration. In cases where such construction will not interfere with the proper disposal of floor drainage, curbs on timber floors should be constructed with ample clearance between curb and floor so that trash may have an opportunity to blow away.

To check the spread of fire lengthwise of the bridge the spaces between stringers, in cases where these rest on the floorbeams, should be filled with tightly fitting diaphragms over each floorbeam. Perhaps the most practicable method is to use wooden diaphragms at least 6 inches thick, which may be made up of two thicknesses of plank spiked together. Strips or battens should be placed around the edges of these diaphragms to cover cracks due to imperfect fitting of shrinkage. The accompanying sketch indicates the recommended construction.

In cases where limitation of headroom is not a factor, fire curtains of sheet metal extending at least five feet below the bottoms of the joists, and spaced at intervals of about 50 feet, will be of material assistance in preventing the spread of fire. The corrugated asbestos covered metal as used for siding and roofing of buildings is suggested for this purpose.

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*Mr. John D. Stevenson, Assistant Chief Engineer of the City of Pittsburgh, makes the following statement:

"The city has several steel bridges having wooden floors. Some of these are large structures crossing the rivers and are important arteries of traffic. During the hot dry periods of the summer, fires on these bridges are very frequent. They are of minor importance only, because we have been successful in extinguishing them before the flames have taken much of a hold. During the last summer, on one bridge fires were a daily occurrence and not infrequently two or three fires occurred in one day."

The Annual Report of the Fire Commissioners of the City of Holyoke, Mass., for the year 1921, states that during the year "the Department responded to 170 fires on the various bridges. The month of June was particularly prominent in this respect, when the Department responded to 64 alarms for bridge fires. This epidemic was lessened in the months to follow through the efforts of the Board of Public Works in sending the sprinkler over the country bridges frequently during the day. While the Department has been very fortunate in the past in extinguishing bridge fires at a minimum loss, there is always danger of such a blaze getting so much headway as to cause the loss of one of the bridges."

In practically all cases, the cause of these fires is stated in the report of the Fire Commissioners to be cigarette stubs.

†Mr. Thomas J. Wasser, State Highway Engineer of New Jersey, states that prior to January, 1922, the old Raritan River bridge at Perth Amboy was decked with closely laid rough plank flooring and that, to his knowledge, no fires were reported during the life of that floor. The deck was replanked with heavier lumber, surfaced on two sides and one edge, and laid with ½ in. openings. Since that time there have been seven small fires on the bridge and it has been necessary for the Department to put on a fire patrol to meet these conditions.

Maintenance.—Floors, ledges and pockets and bridge seats should be kept free from street sweepings and other trash.

In the case of country bridges, particularly timber trestles, all underbrush, small timber, drift and debris, underneath and for some distance on both sides of the bridge should be removed. Grass and weeds should be cut in the early fall and drift should be removed after floods. Where the vegetable growth is heavy, chemical weed killers are recommended as being economical and efficient.

Frequent inspections should be made of any conductors of electricity which may exist on the bridge.

Floors should be kept free from splintered and decayed wood.

Provision for Fire Fighting.—For bridges where watchmen or bridge tenders are employed, water barrels, sand boxes or water mains may be employed to advantage for fighting fires. For bridges not under constant supervision the value of any of the above is questionable although sand boxes would probably be most likely to be ready for use when needed.

Water barrels and sand boxes should be covered and the surface of the water in the barrels should be covered with a light film of oil.

In cold climates freezing of the water in barrels can be prevented by the addition of a suitable amount of calcium chloride.

When water mains are provided they should have hose connections every 50 feet and hose reels every 200 feet. In cold climates they must either be protected against freezing or be kept empty with provisions for supplying them with water under pressure, either from hydrants direct or from fire engines.

Watchmen and drawbridge tenders should be provided with at least one 2½ gal. soda-acid extinguisher. Where aid may be expected from a municipal fire department, there should be provided some means of transmitting alarms. If watchmen or bridge tenders are on duty, a telephone may be considered as a substitute for the more reliable and satisfactory public box on a fire alarm telegraph system.

Maintenance of the under-structure and the use of fire fighting appliances will be facilitated by providing under the bridge floor, on each side of each pier and at intermediate points not more than 100 feet apart, platforms constructed of fire resistive material. Access to these platforms may be secured either by hatchways in the bridge deck or by stairs on the outside of the bridge.

In cases where fire streams from hose and nozzles are available, there should also be provided at 20 ft. intervals, both longitudinally and transversely, openings in the bridge deck to permit the use of cellar pipes, revolving nozzles or similar devices. These openings should be not less than 10 inches in diameter and should be provided with metal covers which can be easily removed but not readily displaced by accident.

Fire Retardant Paints or Treatment.—The weight of the evidence, obtained from laboratories which have investigated this subject, is to the effect that, whatever may be expected from future experimentation, there is at present little that can be accomplished in the way of rendering wood fire resistive by means of a paint coating or other treatment by chemical methods. A paint coating which is not readily combustible may, however, serve to delay slightly the time in which the lumber reaches its maximum susceptibility to ignition. The difficulty with the chemical treatment is that the chemicals will either wash out or, if waterproof, are not fire resistive.

Conclusion.—The investigation having shown that the subect of bridge fire protection is of an importance not previously recognized, the committee desires to emphasize the need for giving consideration to the fire risk in the design of highway bridges. Public officials having bridges in their charge have a clear responsibility in the matter, and the committee desires to call to the attention of such authorities the desirability of protecting bridges by due care in design and construction, by watchful maintenance and by provision for preventing and fighting fires.

The Economic Value of Highway Transport Franchises

Paper Presented Nov. 21 at Joint Session of North Central Division of National Highway Traffic Association and Michigan State Good Roads Association.

By ARTHUR H. BLANCHARD,

President, National Highway Traffic Association and Professor of Highway Engineering and Highway Transport, University of Michigan.

What is a highway transport franchise? Although the phrase "Highway Transport Franchise" has not been officially defined, it may be explained, as used in this paper, in order that the discussion of this topic may be intelligently comprehended. A state highway transport franchise constitutes an agreement between a state controlling body, as the party of the first part, and the highway transport operator, as the party of the second part, covering a guarantee of definite service on a prescribed route under stipulated conditions by the highway transport operator and a guarantee by the state that there shall not be unwarranted, ruinous competition by other highway transport operators.

Highway Transport Services Covered by Franchises.—Highway transport operators operating under franchises are motor vehicle common carriers, as they carry indiscriminately, within reasonable limitations, all persons or commodities, under general conditions of agreement applicable to the whole public, on defined routes according to definite service schedules.

For example, it is evident that the highway transport services rendered in accordance with the following definitions may be covered and controlled by highway transport franchises:

Rural Motor Express pertains to the highway transportation of commodities on defined routes according to service schedules from several producers in a rural district to a terminal with or without return loads being carried from the terminal to the producers or other consumers.

Intercity motor express pertains to the transportation of commodities on defined routes between municipalities according to service schedules with or without service being rendered at intermediate points.

Services That Cannot Be Covered by Franchises.—On the other hand, it is believed that the following defined services cannot efficiently or legally be covered by franchises:

Long or short rural haulage includes all highway transport methods which utilize highways outside of municipalities except intercity haulage and highway transport operating on defined routes according to service schedules.

Intercity haulage pertains to highway transportation of commodities between municipalities except highway transport operating on defined routes according to service schedules.

The same conclusions apply to the commercial transportation of persons.

The legal right of the state to control the operations of common carriers is generally admitted except in the case of interstate common carriers. At the present time, at least 22 states provide in their statutes for some degree of state control over motor vehicle common carriers.

Are highway transport franchises an economic and public necessity? To those familiar with the development of the commercial transportation of commodities and passengers by motor vehicles during the past 15 years in the United States and the longer history of highway transport in Great Britain, the answer is unreservedly in the affirmative.

Why Highway Transport Companies Fail.—Failures of highway transport enterprises are occurring every day due to a lack of knowledge of the fundamentals of the economics, science and art of highway transport. It is reported that 90 per cent of all highway transport companies doing business with New York City as a center fail within three years after entering this field. While 50 per cent may fail due to cut-throat competition by fly-by-night companies, it is conservatively estimated that at least 50 per cent fail because of lack of knowledge of the A B C's of efficient highway transport business methods, cost accounting, management, and the operation and maintenance of equipment. Those interested in the efficient development of highway transport in the United States have a big task before them in bringing to the attention of groups of business men or capitalists, operators and prospective operators of highway transport, the necessity of having connected with their operating organizations men who are thoroughly trained in the methods of highway transport, the interrelationship of highway, railway and waterway transport, highway transport legislation, the fundamentals of highway transport cost and record systems and the principles of highway transport management, together, of course, with a knowledge of the mechanism, operation and maintenance of motor trucks, tractors and trailers.

As an integral part of the essential transportation system of America, it is absolutely necessary that highway transport be placed upon a sound business basis in order that responsible operators may be protected and that this branch of common carrier service may be conducted in such a manner as will guarantee to the public constant, efficient, economic service.

From the standpoint of public safety, the state must insist that our motor vehicle common carriers transporting passengers provide a maximum degree of safety to the traveling public and eliminate reckless driving by inexperienced chauffeurs and the utilization of wholly inadequate motor vehicle equipment which may be characterized in some cases as a piece of junk carrying a packing box in which persons are jammed, the resulting contrivance being called a motor bus.

Powers of State Public Service Controlling Bodies.—Based on an analysis of all state statutes covering the control of motor vehicle operation, the powers given to state public service controlling bodies may be classified as follows:*

1. Grant, refuse to grant, amend or revoke certificates of public convenience and necessity.
2. Prescribe routes.
3. Fix schedules.
4. Determine character of service and promote the comfort and safety of traveling public.
5. Establish fares and rates.
6. Require reports and uniform methods of accounting.
7. Examine accounts and records.
8. Supervise fiscal affairs such as incorporation, capitalization of stock, etc.
9. Compel additions to extensions of or betterments in physical equipment.

Qualifications of Members of State Controlling Body.—If the powers enumerated are given to a state controlling body, what should be the qualifications of the members of such a body? It is evident that a grave responsibility to the public and to highway transport business will rest upon them. They should be men possessing vision, judicial minds, and a broad knowledge of transportation, and should be unprejudiced pertaining to the relative development of railway, waterway and highway transport. Different fields of public and business affairs should be represented. An efficient controlling body might be made up of the Attorney General of the state as an ex-officio member; a highway transport man of high standing and possessing a broad knowledge of the development of all phases of transportation of commodities and passengers by motor vehicles; an experienced highway engineer, who understands the fundamentals of highway transport and who thoroughly comprehends the relationship existing between the economic operation of highway transport and such highway factors as grades, alignments, widths, drainage, foundations, the character and maintenance of roadway surfaces, and the methods of controlling and directing the operation of traffic on highways; a business man who has dealt with big commercial problems; and a banker who is familiar with the practice of bonding common carriers and other enterprises in connection with the operation of which the public must be protected.

To this group of five might be added a steam railroad man and an electric railway man provided that they possess broad vision relative to the development of transportation in America, such as is possessed by W. H. Lyford, vice-president of the Chicago & Southern Illinois Ry. Mr. Lyford's comprehensiive knowledge of the transportation problems of the United States was shown to the public through the medium of his admirable address† before the Second National Conference on Highway Engineering and Highway Transport Education in Washington in October, 1922, during which he vividly outlined the many fields of railway transportation in connection with which highway transport may be efficiently employed and how the improvement of highways and the development of highway transport is of direct benefit to the railroads. At least 90 per cent of the railway officials of the United States could profitably digest Mr. Lyford's conclusions with the result that many would be converted and in the future would not exhibit that narrow-mindedness which has led many to vigorously protest against the use of railroad taxes for highway improvement, and the development of highway transport.

In conclusion, it may be said that, in the opinion of the writer, the highway transport operator of sound financial standing, who is endeavoring to render to the public an efficient, economical and safe transportation service, will welcome the passage of state laws relative to highway transport franchises provided that they are based and administered on the principles which have been herein outlined.

Materials Used in 4 Years State Highway Construction in Pennsylvania

During 1919, 1920 and 1921, and up until Sept. 1, 1922, the State Highway Department of Pennsylvania built 1,620 miles of modern-typed roadway. During the same period its resurfacing operations covered 1,345 miles. Table 1 shows the number of miles of new roadway contracted for during the four years, and the quantities of materials used in the construction:

TABLE I.—MILEAGE AND MATERIAL USED.

	1919.	1920.	1921.	1922.	Total.
Miles placed under contract	686.2	359.1	446.4	405.3	1,897.0
Materials.					
Cement, barrels	1,970,835	1,261,365	1,413,489	1,466,319	6,112,008
Sand, tons	884,561	526 602	601,794	599,475	2,612.432
Stone, tons	1,242,101	731,860	832,337	833,416	3,642,714
Asphalt cement, tons	12,454	1,822	4,540	1,367	20,183
Filler, tons	9,618	1,696	4,225	1,273	16,812
Reinforcing mesh, sq. yds.........	5,066,431	3,394,780	3,893,195	3,959,059	16,313,465
Vitrified bricks	14,636,480	2,886,360	4,972,480	1,725,440	24,220,760

To transport these materials there were required 230,000 freight cars.

The operations of the highway department's maintenance division during the four years resulted in the entire resurfacing of 1,345 miles of macadam roadway and repairs to many additional miles. In this work 3,021,169 tons of stone were used—or a quantity sufficient to fill 67,138 steel hopper cars. This is the stone used by the maintenance division only. If all the materials used by the construction forces and the maintenance division could be hauled in a single train that train would be 2,254 miles in length; and when the caboose of this train was passing Harrisburg, Pa., the locomotive would be 373 miles west of Denver, Col.

Equally vast is the gallonage figure of the materials used by the maintenance division in the surface treatment of stone roads. During 1919, 1920, 1921 and 1922 the asphalts, oils and tars used in surface treatments totaled 22,070,389 gal.—sufficient to fill 2,760 tank cars.

Again This Year—The Snow Must Go.

From The Highwayman, a Publication of the New Jersey State Highway Department.

Probably no work done by the highway department last year was of greater immediate service to the road-using public than the "Snow Removal" program that was carried through so successfully.

This was made evident by the large number of letters we received commending the work, and hoping that it would be continued.

It will be continued. The same volunteer organization of employes of the department, with the co-operation of the contractors, will handle the snow removal work this coming winter.

The works committee meeting of Aug. 28 started a discussion of snow removal subjects and it was decided to start preparation of organization charts in the near future, in order that everything may be in readiness when the snow comes.

Men who have joined the department on a monthly basis this year, it is expected, will join in the work with the same spirit and enthusiasm as others who have been tried by the fire, that is to say, snow.

Safety a Factor in Highway Construction.

Editorial in Texas Highway Bulletin, a Publication of the Texas State Highway Department.

Motor vehicles are driven in many cases by inexperienced persons without proper poise and sometimes by persons who are intoxicated. If the consequences of the acts of these persons fell only upon themselves, we might disregard them as factors in the construction of roads, but when they affect and concern the safety and lives of a much larger group using vehicles and highways with intelligence and care, they must be taken into consideration in highway construction.

Highways must be designed for the reckless, the thoughtless and the intoxicated. Never before in the history of the world were so many instrumentalities of destruction turned loose in the hands of persons so ill-fitted to direct them.

With 9,750,000 motor vehicles in the United States at the present time, and every reason to believe that it will be double that number in fifteen years—we can see the urgent need of designing and constructing our roads with this in view.

33⅓ Miles of Bridges on Federal Aid Roads.—A total of 33.3 miles of bridges, exclusive of small structures, have been completed on Federal aid roads.

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*Report by Motor Vehicle Conference Committee, March 1, 1922.

Waterworks and Hydraulics Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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Edison Versus The Pedagogs

For more than a generation it has been a principle of pedagogy that students should be urged not to commit to memory many facts. General principles should be memorized, they admit, but "details," not. Now comes Edison with an examination of applicants for positions in his research laboratories, and, behold, he demands not merely men who have read widely but who have retained a vast amount of detail. Since most of us had been taught that it sufficed to know where to look for information without having more than general principles committed to memory, it was to be expected that Edison's examination questions would arouse the criticism of nearly every editor. But let us not be too sure that the vote of one great thinker does not out-ballot the votes of a thousand lesser men.

The writer has held, for some time, that all thinking is, in the final analysis, nothing else than a form of memory. The "experienced" man is one whose mind is stored with facts. His advantage over the "inexperienced" man lies almost entirely in the command that he has of a greater number of facts applicable to the case in hand. Note also the significance of the statements found in so many biographies of great men, namely, that they had prodigious memories for matters that related to their specialties.

Memorizing has often been decried as "parroting," but true parroting is mere repetition of sounds without understanding their significance. Effective memorizing is quite a different process.

Read, therefore, not merely to learn where to find usable details and data, but to record as many of them as possible on the tablets of your brain. In short, follow Edison's practice and not that of those who rail at his theory while conceding the merits of the results that he obtains by applying it.

The Desirability of Simple Utility Rates

The higher courts, in ruling upon the regulation of public utility rates by councils and commissions, have clearly established the principle that a rate should not be more than what the service is worth to the customer nor less than will yield a fair profit to the utility. As it is much easier to determine the cost of rendering these services than to find what they are worth to the users, and furthermore because many public services such as domestic water supply are of very nearly inestimable value to individuals, the scientific determination of rates has been conducted for the most part on the basis of cost of service only.

In order to keep the matter in a practical working form, numerous minor factors have been ignored, and some of the most carefully worked out rates have been of the "three-way" type, in which there is first a "customer's charge" of small amount to cover the cost of bookkeeping, meter reading and other small items which are practically the same for all customers; second, a "demand charge" in which the customer is charged with an amount proportional to the total demand for service that he may make upon the system at one time, and which is intended to cover such items as interest on plant, rentals, portions of plant attendance, etc., which are controlled, not by the amount of product or output of the plant but by the amount of plant which it is necessary to maintain to meet the demands of customers; and third, a rate to be paid for the product consumed—gallons of water or kilowatt hours of electricity for example.

While such rates have much to recommend them, and while it is sometimes necessary to introduce still other factors, such as load factor, power factor, etc., into the rates of large consumers, in the case of small domestic customers the simpler forms possess some advantages which have led to their general retention up to the present time. The three-way and other multiple-factor rates involve a little more clerical and inspection service and consequent expense to the utility, so that for monthly bills of small amount both parties lost much of their benefit. A further serious objection lies in the difficulty that the customer finds in understanding them. It is only human that this lack of understanding should lead in numberless cases to the thought that something is being put over on the consumer by the utility; and such suspicions, however rarely justified, have been factors in developing the frequent public hostility to utility corporations, which has cost them so greatly both in peace of mind and in good hard profits.

The simplest rate, obviously, is the flat rate, which in its better forms is substantially a demand rate. The flat rate's vital defect of affording no incentive to economy of use has led to its almost complete abandonment for electric service. For water supply it still remains in favor in many places—due most often to lack of understanding by a large body of water users, frequently aggravated by ignorant or malicious political activities. The flat rate for water is least objectionable where there is an abundant gravity supply, but even there the waste to which it leads requires a much larger installation of supply lines and mains than would be needed otherwise, thus adding to the interest and maintenance charges which the customer must bear. Where pumping power is required the flat water rate results in exactly the sort of waste that has lead to the near universal installation of meters on electric services.

Next to the flat rate in simplicity is the rate based wholly on quantity of product consumed. Few users find difficulty in understanding it, for a thousand gallons of water or a thousand cubic feet of gas are very simple and understandable things; while the kilowatt hour has at least a very general public acceptance as being understandable, and by analogy, a measure of real understandability to persons having no general electrical knowledge.

It seems likely that a meter rate graduated to give increased consumption an approximation to what would be paid under the more complicated systems will remain in favor for a long time. As a feature such a rate should carry a minimum charge which is substantially the customer's charge previously referred to. The absorption of this charge in the payment for the first, or top rate, lot of water, electricity or gas is almost universal, and where both charge and rate have been worked out properly, leads to only minor variations from what would result from a rate involving more factors and calculated with greater precision. If it failed to work thus, the simple rate would of course have to give way. Perhaps the most common defect of such rates has been the establishment of too low a minimum.

Asleep at the Post

From the terrors of the coal strike we have escaped as a nation with the minor punishment of an increase in our fuel bills. We have not suffered the crippling of industry and the discomforts of heatless homes which were threatened; and with childish abandon we seem to have forgotten that these things not only might have, but still may, happen to us.

The strike was settled on a basis which makes the consumer pay the bill, but worse still, it was settled in a way which no one believes will be permanent. On December 7 the first of the series of conferences between operators and miners to work out a permanent plan adjourned without results, and we have the threat of a strike renewal next April.

The National City Bank Bulletin says that the most serious factor of the immediate future for this country is "the prospect of another coal strike in five months." The strike, if renewed, will be more bitter than its predecessor and may easily carry us to the catastrophe that was so generally feared a few months ago.

The concern of the the "ordinary citizen" and in particular of the engineer in this matter is plain enough, but he is indisposed to act so long as he is not actually suffering from its effects. This indifference must be overcome, and speedily. The president has appointed a particularly able coal commission. It is provided with fair financial resources for carrying on its work, and it ought to accomplish much. But without a positive public support, it will lack effectiveness.

The prevailing lack of public interest is pretty clearly reflected in the meager attention given by the daily press to the appointment and plans of the commission. Here and there a monthly or a weekly publication has raised its voice in warning, and to these we add our own exhortation that our readers keep in touch with the subject and that they make their interest felt by discussing it both in private and in public. If we sleep at our posts now, we cannot escape a large measure of blame if we awake hurt in business and shivering in body.

Why Not Courtesy?

Recently the editor was shown a small town electric lighting bill, on the back of which was printed a statement of the terms under which the service was rendered, conspicuously calling attention to the promptness with which the service would be discontinued in default of prompt payment and the fact that no further notice would be given. The language had just enough of the bullying spirit to anger the recipient of the bill, although scarcely enough to warrant a formal complaint.

The attitude indicated in this small way was formerly common among privately owned utilities, and was often expressed in much more objectionable form. The private corporations, even where they had monopolies, slowly learned that such an attitude did not pay, and they have very largely adopted an entirely different one. The lighting bill mentioned was from a municipally owned plant, the management of which may have considered that courtesy was quite unnecessary. Undoubtedly it will be long before the fallacy of such an attitude is fully appreciated, but until it is, the friction it produces will cause much needless waste of energy.

Prompt payment can be assured without insult, and so also can many other necessary ends, the statements of which are too often couched in irritating terms. In one sense only are these matters small. Their improvement would add greatly to the ease of daily life and business.

Meeting of Illinois Society of Engineers.—The annual meeting of the Illinois Society of Engineers will be held at ePoria, Ill., on Jan. 23 to 25, 1923. The secretary is E. E. R. Tratman, of Wheaton, Ill.

The Salaries of Waterworks Superintendents.

To the Editor: I have noticed the editorial on page 2 of your Waterworks issue for Oct. 11, entitled "How Can Water Works Superintendents Secure Adequate Salaries," and feel that some of the statements therein should not have passed over without comment.

If your statement is true that the average water works superintendent is disgusted with the treatment that he is receiving, it would follow as a consequent fact that the management and general condition of the average municipal water works plant must be in a rather deplorable state from the tax payer's and consumers' standpoint, as well as the technical view point.

In cases where a man is so disgruntled that, as indicated by your editorial, he may improperly or neglectfully handle his work, he is not in a frame of mind to best serve the interests of the public; the chances are that he would be dissatisfied at any reasonable salary and his work would undoubtedly be better done by another at a suitable compensation, who has already proven that he intends to do his best at whatever he attempts, regardless of what he may be paid, using his current position as a stepping stone to better achievement.

No man, in my judgment, should win promotion or increased compensation if he fails in efficiency in the position he already occupies, whether or not he considers his salary at the time adequate, for he thereby demonstrates that he is unworthy of favorable consideration.

Leaving out the matter of politics, the average city councilman would, I think, hesitate to vote for more money for a head of a department who was known to be disgusted and was "laying down" on his work, but on the contrary would be ready to reward one who was of an efficient and progressive disposition and used his existing position as a stepping stone to better achievement.

There is no question but that the average water works superintendent is underpaid, and many are working with enthusiasm for the love of their work under adverse and disappointing circumstances. I am thoroughly in sympathy with all efforts to better existing conditions where warranted, but believe such efforts should be made on a basis of services rendered and efficiency, and not because a person slows up in his work on account of dissatisfaction.

EDWIN H. ROGERS,
City Engineer.
Newton, Mass.

The Service Charge.

To the Editor: In your waterworks issue of Oct. 11, appears an article entitled "The Service Charge" that carried to me a novel argument for the basis for service charges in the use of water meters.

The argument that the more water a consumer uses the more he should pay for the use of the paraphernalia necessary to supply him seems to me a novel one. As well say that when I send to the city scales a ton of coal to be weighed, the charge for which is 20c—if I send to the same place a load that weighs 5 tons to be weighed I should pay $5 for the privilege, on the same proportion as the service charge is worked out in the article referred to. That is the scales are capable of weighing more than I send and if the compensating weight has to be moved farther along the balance beam I must pay more for the same service.

On the same basis if I buy a quart of milk for 14ct. the cost of the bottle being about 8 ct., 1/6 of which is charged in the price of the milk, if I buy an 8 quart can of milk I would be obliged to pay 14 ct. per quart plus 33c for the use of the 8 quart can ($2.00 per piece being market price of 8 qt. cans at present), or in other words 33 ct. for the use of the can plus $1.12 for the milk or $1.45 for the 8 quarts or as it figures 18 ct. per quart. This does not seem equitable and any firm of milk dealers or public weighers doing business on this basis would soon find their customers going elsewhere.

The whole story seems to be argued from the wrong standpoint and is apparently the idea to get from the service all the traffic will stand. The system of charging for the use of meters seems wrong in principle; the water charge is a tax although worked out on a commodity basis. All water used throughout the city for watering streets, flushing sewers, fountains, fires and the like must be paid for and as all receive the benefit all should pay the established rate, whether much or little, at the price per gallon or foot irrespective of the amount used or the size of the meter.

The subject of charges for the use of meters was finally abolished in this city, it was always a bone of contention and argument so the system was changed. The city owns, installs, repairs and removes all meters and the cost of this service is all charged against the consumer in the fixed price for the water and all pay their share of the whole cost. We find this to be the best way and see no good reason for going back to the old system of charging for meters.

On the subject of the use of meters for the basis of charging for water there is no argument—it is the only fair way to sell water service. It eliminates waste, makes for satisfaction to the consumer as he knows the more he uses the more he pays while if he is careful his bill will be small in proportion.

L. P. SAWIN,
Income Division, Water Department.
Everett, Mass.

Soil Corrosion Investigations of U. S. Bureau of Standards

The damage to buried pipe structures due to the corrosive action of soil is known to run into enormous sums annually. In order to throw further light on the ways and means of reducing losses from this source, the Bureau Standards instituted, about a year ago, a very comprehensive investigation into the entire subject. This investigation has been undertaken with three main objects in view: First, to determine what types of soils throughout the country are especially corrosive to iron and steel; second, to determine which kinds of iron and steel pipe are most resistant to the corrosive action of particular types of soils, and, third, to investigate the most practical means of reducing damage from this cause.

The work is carried on with the active co-operation of the principal manufacturers of iron and steel pipe, and the large public utility corporations throughout the country as the principal users of pipe, and with the Bureau of Soils of the Department of Agriculture. The steel interests and the public utility interests are incurring the major part of the expense of the investigation. The Bureau of Standards plans and directs the work. Approximately 9,000 specimens of the pipe have been furnished free of charge by pipe manufacturers.

During October the last of these specimens were buried. The tests are being made in 46 different soils in as many separate locations widely scattered throughout the United States. They represent practically all the principal soil types to be found in this country. It is planned to start taking these specimens up for examination after they have been down about a year. This work will be started in February in the southern district where the pipe specimens were buried last winter. It is expected that the more corrosive soils will yield considerable information on the first examination and the less corrosive soils will require a longer period. The investigation will be continued for a period of at least 8 to 10 years, specimens being taken up for each location about every year or two for examination. The field work is being supplemented by a series of laboratory investigations that have a direct bearing on the soil corrosion problem.

Owing to the very urgent demand from many sources, it is planned to increase considerably the scope of this investigation. The brass manufacturers have requested that numerous brass specimens be included in the test, particularly of fixtures designed to be used with wrought iron and cast iron pipes. It is planned also to include a considerable number of specimens of pipe coated with various types of protective coatings. These will include some additional specimens of pitch treated pipe, but will more particularly refer to metal covered pipe, such as those covered by the various processes of galvanizing, also lead covered pipe for which rather strong claims have recently been made. Arrangements have been made with the manufacturers of galvanized pipe and lead covered pipe to furnish the necessary samples. These will be buried at the various locations when the first inspection of the iron pipes is made.

Anti-Mosquito Conference in Florida

An anti-mosquito conference under the auspices of the State Board of Health of Florida was held at Daytona, Fla., on Dec. 6th and 7th. This conference was the culmination of a season's intensive work by Chief Sanitary Engineer George W. Simons, Jr., under whose direction the details of the meeting were arranged. At this very important conference the general problem of mosquito eradication was discussed and ways and means developed for attacking the problem on a large scale. It was the first of such conferences in Florida. A special appeal has been made to members of the engineering profession to become identified with this program and take the initiative in its launching.

Loss of Head in Bends of Less Than Ninety Degrees.

BY F. W. MEDAUGH.

Instructor in Civil Engineering, The Johns Hopkins University.

Experiments made recently in the hydraulics laboratory of The Johns Hopkins University indicate that the coefficients suggested by Mr. W. E. Fuller (Journal of New England Water Works Association, December, 1913) for loss of head in bends of 45 degrees and 22½ degrees are insufficient for bends of small radius.

The total loss of head due to bends which is in excess of that occurring in an equal length of straight pipe may be divided into three distinct parts: an eddy loss occurring in the straight pipe above the bend, a loss in the bend proper due to impact, and an eddy loss occurring below the bend. Observations on bends of small radius made both by taking piezometer readings and by obtaining the actual hydraulic gradient through the insertion of a row of glass tubes, show that the loss in the bend proper is small compared with the eddy losses. The hydraulic gradient for the bend proper was a straight line for both the inner and outer stream lines. The slope of the inner shorter hydraulic gradient was steeper than that of the outer hydraulics gradient but the total drop was the same.

If 90 degree bends or bends having equal central angles are experimented with, as the curvature of the bend is decreased the loss per foot in the bend proper will slowly decrease but the total loss in the bend proper will increase, due to the greater length of curve. At the same time the eddy losses will decrease so rapidly that the total loss of head will decrease until a critical radius of from 2 to 6 ft. is reached. From this point on, the increase in loss in the bend proper more than offsets the further decrease in eddy loss and the total loss increases.

Obviously if a bend of 45° or 22½° is used instead of 90°, the loss in the bend proper is decreased while the eddy loss remains unaffected. Decreasing the central angle of the bend will reduce the total loss of head for the bend by a much larger percentage when bends of large radius are used than it will when bends of small radius are used, for the eddy loss forms a much smaller percentage of the loss on bends of large radius than it does in bends of small radius. An arbitrary allowance of ¾ for bends of 45° and ½ for bends of 22½° is inadequate for sharp bends and entirely too large for bends of large radius. Of course, Mr. Fuller intended that this rule should be applied to bends commonly found in water works practice but even here the allowance in many cases is probably a trifle inadequate, particularly for the 22½° bends.

Another factor which will affect to a minor extent the loss of head in bends is the placing of one bend in close proximity to another. If the eddying regions merge to any appreciable extent it is possible that the total eddy loss will be decreased.

There is need for further experimental work on the loss of head in bends which will fully take into account the eddy loss above the bend and which will keep separate and distinct the three different losses occurring in each bend. It may be that the pipe diameter has little effect on the loss in the bend proper and that some simple relationship can be worked out between the eddy losses and the pressure differences between the outer and inner stream lines in the bend proper.

Use of Labor Saving Equipment at New Bedford, Mass., in Laying 48-in. Main.

BY STEPHEN H. TAYLOR.
Superintendent Waterworks, New Bedford, Mass.

In 1920 the New Bedford Water Department had about 6,600 ft. of 36 in. cast iron main pipe to lay in addition to the ordinary yearly extensions, and as labor was scarce, it was decided to purchase a steam shovel, self-propelled, with an extended dipper arm for trenching. In 1921 when the laying of about 3½ miles of 48 in. cast iron main was started, a clamshell and crane machine with caterpiller type traction and 30 ft. boom was purchased. These machines have proved great money savers on the large pipe line work which has been done in the past three years.

The latter machine is used for pipe laying, and in places where the ground is too soft to support the steam shovel over the trench, excavating is done with the clamshell outfit on the same machine. It is also used for driving piles, which are needed as a foundation for the pipe through a swampy section. Under ordinary conditions the excavation is done by the steam shovel traveling on platforms over the trench with the crane following close behind, handling the pipe. The shovel deposits the excavated material into trucks which haul it directly to the backfill close behind, or to the spoil bank.

Excavating Trench With Steam Shovel.

With reasonably good conditions from 120 to 180 ft. per day of trenching 8 ft. deep by 6 ft. wide; pipe laying and backfilling is accomplished with a crew of from 15 to 20 men, two or three trucks, and the steam shovel and crane. The advantage of a small crew is particularly great in our present work, which is 10 to twelve miles from the city, and as there is very little local labor available the men must either be boarded near the work or transported to and from the job. These machines have made it possible to keep the number of men small enough to be easily transported.

All sorts of excavating conditions, including ledge, hard pan and boulders, wet and dry gravel, and swamp muck, have been encountered, and this outfit has been able to handle all of them without resorting to sheet piling the trench. In some instances quick work was necessary to get a single pipe in a trench 12 ft. long before the sides caved in.

With the crane a 48 in. pipe weighing about 4½ tons is taken from the bank and laid to line and grade in 5 or 6 minutes.

The average cost per foot for the 6,800 ft. of 48 in. cast iron pipe laid in 1921, including a cross connection was, $17.29, for pipe, specials, gates, hydrants and $11.43 for labor and all other expense, including a proper proportion of the cost of the shovel, crane and other equipment.

Lowering Pipe Into Trench With Crane.

The cost was further reduced by the use of "Leadite" and a braided jute yarn for making joints. No bell holes are required when using "Leadite" as no caulking of joints is necessary. In some of the very swampy sections, encountered in this work, this is a very important feature.

The yarn is braided ½ in. square. It is cut to proper length and tamped by hand into the joint. This saves wastage of material and labor, twisting and caulking the yarn and makes a better joint. There are no loose ends of fiber to mix with the jointing material and reduce its efficiency.

Pile Driving Through Swampy Section.

Maximum Discharge from Spillway Since Opening of Panama Canal

Eight of the 14 gates of the spillway of Gatun Lake were opened at the same time during experiments conducted on Oct. 27. This according to the Panama Canal Record, gave the greatest discharge since the completion of the canal. The discharge was estimated at about 104,000 cu. ft. per second. In the past 8 years 6 and 7 gates have readily taken care of necessary spilling to prevent the surface from rising to a level higher than desired, and it is likely that the necessity for using 8 gates or more will be very rare.

The use of 8 gates was simply for experimental purposes, as the use of one gate during from about 12 to 18 hours is usually sufficient to discharge the normal surplus at this time. The object of the experiments was to ascertain the best combination of gates to allow a heavy discharge without affecting seriously the operation of the adjacent hydro-electric station through the action of backwater in the tail race; without causing water to leap over the opposite or west wall of the discharge channel; and without allowing a dangerous concentration of rushing water against any of the piers of the railroad bridge across the discharge channel.

It was found that by selecting gates so that the discharge currents counteracted upon each other, 8 could discharge simultaneously without serious effect, and probably 10. The capacity of the hydro-electric station was reduced temporarily about 15 per cent. by the height of water in the discharge channel. The west wall of the discharge channel, and the piers of the bridge were not damaged.

Records were made of the currents set up near Gatun Locks, moving toward the spillway as the result of the abnormal discharge. A maximum current of .6 knot was observed at a depth of 5 ft. below the surface, and a maximum of .24 knot at 15 ft. below the surface.

The rate of discharge can be imagined from the fact that for the entire year 1921 the water used for supplying the cities of Panama and Colon and all of the Canal Zone municipal systems and in leakages at spillways and locks, aggregated 1,670,000,000 cu. ft. In the experiments at the spillway 535,000,000 cu. ft. were discharged in 2 hours—enough for the municipal uses for 4 months.

Short Course for Water and Filter Plant Operators

The fifth short course of instruction for municipal waterworks, attendants bureau filter plant operators will be held at Dallas, Texas, during the week beginning, January 15, 1923. The course, as in previous years, will be conducted under the auspices of the city health department of Dallas, the state health department and the Texas water works association. There is no charge for tuition or laboratory fees and anyone interested may attend. Dr. W. T. Davidson, director of public health, municipal building, Dallas, is in charge.

The Design of Masonry Dams

Historical Examples and Evolution of the Theory of Design

By EDWARD WEGMANN,
Consulting Engineer, New York City.

A slight condensation from a paper presented before the International Congress of Engineers at Rio de Janeiro, 1922, and here printed in Two Parts—Part II to appear in Engineering and Contracting, Jan. 10, 1923.

PART I.

As early as 1888, the author proposed in the first edition of his book on "The Design and Construction of Dams" two practical profile types, numbered No. 1 and No. 2, for a masonry dam, built on an ordinary good rock foundation. Both are based upon the simple theoretical triangular profile. The merits of these economical profile types are beginning to be realized. Practical Profile Type No. 1 was adopted in 1911 for the masonry dam, 164 feet high, built across the Medina River, near San Antonio, Tex., and the profile of the Don Pedro Dam in California, which is 279 feet high, is made according to the author's Practical Profile Type No. 2. The profiles, according to which the San Antonio and Camarasa dams in Spain, respectively 269 and 335 feet high, were built, are very similar in design to the author's Practical Profile No. 2.

An Early Irrigation Dam.—The first masonry dams of importance in Europe were built in the southern part of Spain in the latter part of the 16th century, to form reservoirs to supply water for irrigation. The Almanza Dam, built in the Province of Almanza near the town of this name, is the oldest of these structures. The exact date of its construction is unknown, but, according to old documents, it was in use prior to 1586. It has a maximum height of 20.69 meters (about 68 feet) and a length on the crest of about 90 meters (292 feet).

Although the profile of this dam was not well designed, it is an interesting fact that its masonry has sustained safely for over three centuries a maximum pressure of 14 kilos per square centimeter (14.33 short tons per square foot).

The highest of the old Spanish dams is that of Alicante, named, also, after a village near its site, the Dam of Tibi. Its designer is supposed to have been Herreras, the famous architect of the Escurial Palace.

The dam is built of rubble masonry, faced with large cut stone, and is curved in plan to a radius of 107.13 meters (about 351.4 feet). Its greatest height on the upstream side is 41 meters (134.5 feet) and the maximum pressure in the masonry is 11.28 kilos per square centimeter (11.54 short tons per square foot).

The Puentes Dam, nine meters higher than the Alicante reservoir wall, was built in 1785-91, and was considered to be one of the great achievements of Charles III and Charles IV of Spain. It was 50 meters (164 feet) high and had a crest length of 282 meters (925 feet) (Fig. 1). The dam was finished with a magnificent parapet, upon which colossal statues of the two kings mentioned above were to have been placed.

According to the original plans, the dam was to have been founded entirely on rock. In the center of the valley, however, a deep pocket of earth was encountered, and it was unfortunately decided to build the dam at this place on a pile foundation. This foundation was built very securely and might have proved to be satisfactory if the depth of the water in the foundation had been less. For eleven years the dam stood successfully, but during this time the depth of the water in the reservoir never exceeded 82 feet. When, however, in April, 1802, the water was allowed to rise in the reservoir to an elevation of 154 feet above the base of the dam, the pile foundation gave way, and the wall was ruptured, causing a loss of over 600 lives and a large amount of property.

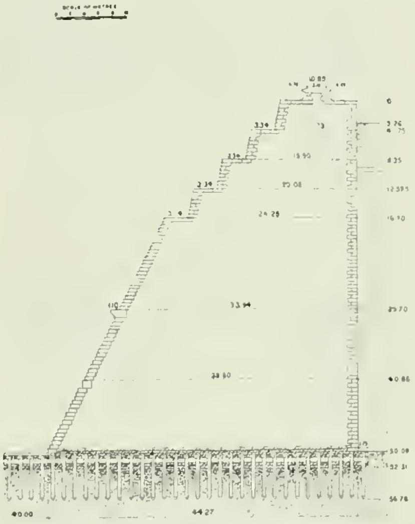

Fig. 1.—Puentes Dam, Spain—Built 1785-1791—Failed 1802.

Prior to the middle of the last century, several other masonry dams were built in Spain and a few, comparatively low structures of this kind, in France. None of these dams were designed according to correct principles.

It has been pointed out that some of these reservoir walls would have been stronger if part of the masonry they contained had been removed. There was no theory of the proper design of masonry dams in those days.

The Work of Sazilly and Delocre.—The French engineer, M. de Sazilly, advanced the first rational theory for the design of masonry dams in a memoir published in the "Annales des Ponts et Chanssees" for 1853, 2nd semestre, pp. 191-222. According to Sazilly, the safety of a dam depends upon its compliance with the following two fundamental conditions:

1. The pressure sustained by the masonry or its foundation must never exceed a certain safe limit.
2. There must be no possibility of any portion of the dam sliding on that below, or of the whole wall's moving on its foundation.

Sazilly was unable to devise a formula for the design of the profile of a masonry dam, which would contain both of the above conditions. As he knew, however, of no case where a dam had failed by sliding, he recommended that the design of the profile be based only on the first condition, leaving it to a subsequent calculation to investigate whether the dam had a sufficient factor of safety against sliding. If the profile was found not to give sufficient strength in this respect, then Sazilly recommended that the profile should be redesigned for a lower limit of pressure.

Sazilly pointed out that in determining the greatest pressures that might occur in the masonry, two extreme cases should be considered:

1. Reservoir full.
2. Reservoir empty.

These two conditions give the extreme positions of the lines of pressure in a dam, the first causing the greatest pressure in any horizontal plane to occur at the front (downstream face) of the dam ,while the latter produced them at the back (upstream face) of the dam. For economy's sake, a dam should have the minimum profile complying with the given conditions. Having adopted a fixed limit of pressure, Sazilly's ideal profile is that in which the greatest pressures at both faces just reach the adopted limit. Sazilly called this design the profile of equal resistance. As he was unable to find formulas that would give the proper curves for the faces of a profile, he proposed using a stepped profile (Fig. 2) and making the calculations for strength for each course of masonry. It is evident that a stepped profile involves a waste of masonry and is certainly not the most economical type of profile.

In connection with the design of large storage reservoirs, to prevent frequent inundations iu the valley of the Loire, France, the engineers found suitable sites only in the upper branches of this river, but, in order to attain sufficient storage capacity, dams up to 50 meters (164 feet) in height are required. As it was deemed hazardous to construct them of earth, it was decided to build them of masonry. The study of the best type of profile for such a dam was assigned to M. Delocre, who designed a profile with polygonal outlines (Fig. 2) and obtained rather lengthy equations, some of them of the 6th degree, for determining its form. Compared with Sazilly's stepped profile type, for a dam 50 meters high, calculated for a limit of pressure of 6 kilos per square centimeter (about 6 short tons per square foot). Delocre's polygonal type has 33.45 square meters less area of profile.

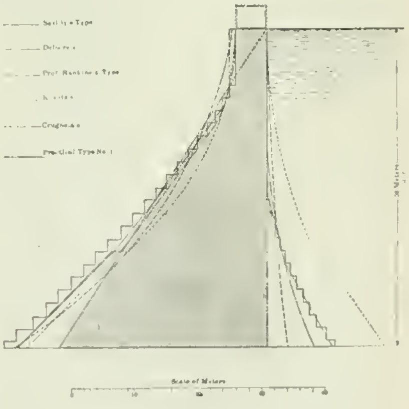

Fig. 2.—Comparison of Profile Types.

The results of Delocre's studies were known in 1858, formed the basis of the design of the Furens Dam, near St. Etienne, France, 50 meters high the first masonry dam, designed according to correct principles. It was not, however, until after the completion of the construction of this dam, that Delocre published in the "Annales des Ponts et Chansees" for 1866 a memoir giving the details of his researches.

Prof. Rankine's Improvements in the Theory.—The next engineer to take up the difficult problem of the design of a profile of minimum area for a masonry dam was Prof. W. J. M. Rankine. In connection with some proposed reservoirs for the city of Bombay, India, the question arose of deciding between the respective merits of earthen and masonry dams. This question was submitted to Prof. Rankine, who was asked to make a rigid mathematical investigation of the best form of profile for a masonry dam. The report[*] written by Prof. Rankine in response to this request is very complete, and contains some new principles that should be considered in designing the profile of a masonry dam. While Rankine adopted the principles laid down by the French engineers, he added the very important condition that no tension should occur in the masonry. Theoretically this would take place whenever the line of pressure, reservoir full or empty, lies outside of the center third of a dam.

Rankine's Safe Limits of Pressure.—Rankine, also, pointed out that a greater limit of pressure could be used at the up-stream side of the dam than at the down-stream face. In the former case, the resultant pressure is vertical, but in the latter case it is inclined. The French engineers had only considered, for the case of "reservoir full" the distribution of the vertical component of the inclined resultant pressure. Evidently the maximum pressures in a plane normal to the inclined resultant pressure might exceed those caused in a horizontal plane by the vertical component of the resultant. Rankine did not attempt to determine the ratio of the vertical pressures at the down-stream and up-stream faces of the dam, but, guided entirely by what experience had proved to be safe, he adopted the following safe limits, which the vertical pressures in the masonry were not to exceed at a depth of 150 feet below the top of the dam.

At the down-stream face 15,625 lbs. per square foot.

At the up-stream face 20,000 lbs. per square foot.

The former pressure is practically the maximum pressure existing at the down-stream face of the Furens Dam. Below the depth of 50 meters from the top of the dam, Rankine recommended that the limit of pressure at the down-stream face be gradually reduced, as the batter of the front face increases, in order to make some allowance for the increasing inclination of the resultant pressure.

The Search for an Ideal Profile.—The conditions given by Rankine do not prescribe any definite form of profile, but when we seek the profile of minimum area, the choice of form becomes very limited. The formulas of Sazilly and Delocre for determining the profile of a dam involve very lengthy calculations. Rankine endeavored to find simple formulas. One of the effects of his using a higher limit of pressure for the back (upstream) face than for the front face was to reduce the batter of the latter considerably from that of the French types of dam. Under these circumstances, the vertical component of the water pressure on the back face adds but little to the stability of the dam. By neglecting this component in the formulas he devised, Rankine introduced a slight error, but it is in the direction of safety and simplifies the formulas very much. The profile type (Fig. 2), designed by Prof. Rankine, accompanying his report is bounded by logarithmic curves, and the formulas given for determining the width of base and area of profile for any height of dam are exceedingly simple, but they determine only this one profile, based upon certain given data, viz.: weight of masonry and given limits for the pressures at the front and back face of the dam. If we change these data, the formulas given by Rankine for his profile type are no longer applicable, and the general formulas which we would have to apply in this case are as Rankine says: "Incapable of solution by any direct process." They can, however, be solved approximately by a process of trial and error, involving the higher mathematics.

The Toolsee Dam, 79 feet high above bed rock, was built according to Rankine's logarithmic profile, to form a reservoir for the water supply of Bombay, but, as far as the author knows, it is the only dam of this type.

Empirical formulas for determining the profile of a masonry dam are given by Molesworth in his "Pocket Book of Engineering Formulas," and by others. A method consisting partly of equations and partly of trial equations is published in the Proceedings of the Inst. C. E. for 1885-86, and various profile types, for which no formulas are given, have been proposed by Harlacher, Krantz, Crugnola and other engineers. The principal examples of the profile types we have mentioned above are given in Fig. 2, as, also, a profile type, designed by the author, called Practical Type No. 1, which will be discussed later.

Analysis of Pressure Stresses.—How does the pressure it has to support distribute itself in the masonry of a dam on the foundation? In our present state of knowledge, we do not know. Practically all writers on the subject of masonry dams have assumed this pressure to be distributed as uniformly varying stress, a hypothesis, which seems safe, as it exaggerates, in all probability, the pressures at the faces of the dam, where the masonry is weakest.

Experiments with Models.—Experiments have been made on models of a dam, made either of wood or of some plastic material, to determine the distribution of pressure in a dam. L. W. Atcherley, Demonstrator of Applied Mechanics, University College, London, made the first experiments of this kind in 1904, using models made of strips of wood glued together. Much more satisfactory tests on models of dams were made in 1908 by Sir John W. Ottley and Prof. Arthur W. Brightmore (see Proc. Inst. C. E., 1908, Vol. 172, p. 89) and by John S. Wilson and William Gore, published in the above volume, p. 107. The former experimenters used models made of plasticine, a kind of modeling clay, and the latter used models of india rubber. These experiments, which were carried on for more than a year on models of ordinary types of dams, proved the following facts, which have generally been accepted by engineers, viz.: (1) Tensile stresses, which may have large local magnitude, occur at the upstream toe of a dam; (2) tensile stresses occur at no other part of the dam; (3) owing to the fixity of the base and the change of water pressure at the base, the stresses on the foundation are distributed almost uniformly; (4) for joints above the foundation the usual assumption of the linear distribution of normal stress on the horizontal planes is approximately correct, and overestimates somewhat the maximum intensity of stress; (5) the maximum compressive stresses at the down-stream face occur on planes normal to that face; (6) near the base of the dam, the maximum compressive stresses on horizontal planes do not exceed those calculated on the assumption of linear distribution of normal stress.

Later Methods.—A new method of designing the profile of a masonry dam, based upon the above principles, is given by Arthur A. Stoddart in Proc. Inst. C. E. 1916-17, Vol. 203, p. 401.

The fact that the maximum pressures at the down-stream face are parallel with that face was pointed out by Prof. Rankine as early as 1871. This principle forms the basis of the latest French method for designing the profiles of masonry dams, viz.: that of Maurice Levy (see Annales des Ponts et Chanssees, 1897, 4 Trimestri, and Comptes Rendus de l'Academie des Sciences, Paris, May 2 and July 4, 1898).

Distribution of Pressures.—Before proceeding with our study of the evolution of the theory of the proper design of the profile of a masonry dam, let us consider what is meant by the distribution of the pressures in a masonry dam, according to the laws of a uniformly varying stress. This means that, according to circumstances, the pressure in a masonry wall is either uniformly distributed on the foundation or on any assumed horizontal joint, or varies uniformly from one face of the wall to the other.

Four cases, illustrated by Figs. 3 to 6, may occur. If the resultant pressure is at the center of the base, and the diagram showing this distribution and the corresponding reaction of the foundation of the dam (Fig. 3) is a rectangle. If the resultant pressure is not at the center of the base, but lies within the center-third of the base, the diagram representing the distribution on the base and the corresponding reaction is a trapezoid. (Fig. 4) When the resultant is just at the limit of the center-third of the base, the distribution of pressures is shown graphically by a triangle. (Fig. 5) If the resultant pressure lies outside of the center-third of the base, the distribution of pressure is represented by two triangles (Fig. 6), one representing the positive stress (pressure) and the other the negative stress (tension). To avoid the possibility of tension existing in the masonry, Prof. Rankine recommended, as already stated, that the lines of pressure, for reservoir full or empty, should always be kept within the center-third of the base of a dam, or of any assumed horizontal joint. The shaded areas in Figs. 3 and 6 show the total pressure and the ordinate between the base line and the inclined line represent the pressures at any given point.

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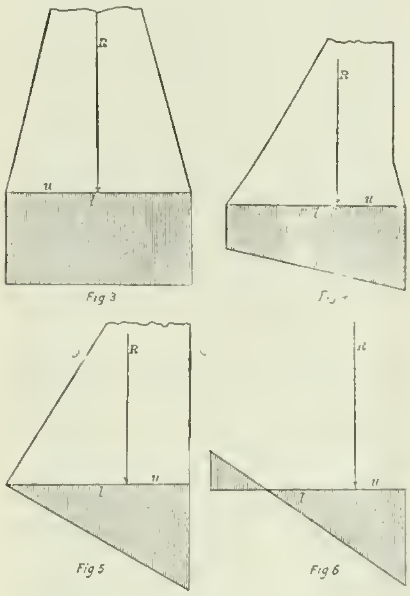
[*] See Prof. Rankine's "Miscellaneous Scientific Papers," 1881, and The Engineer, London, Jan. 5, 1872.

All mathematical methods of designing the profile of a masonry dam are based upon the distribution of pressure in the masonry, according to the laws of a uniformly varying stress, explained above. Great caution must be used, however, in dealing with the case where the resultant pressure is sufficiently eccentric to produce tension. The usual method in such cases has been to neglect the tension and to consider the total pressure to be distributed on only part of the joint. In a well designed dam this condition ought never to exist.

Forces Involved.—All the early writers on the subject of masonry dams considered the wall to be acted on only by two forces, viz.: The water pressure against the back of the dam, and the weight of the masonry. The failure of the Bouzey Dam in France in 1885, causing great loss of life and property, and the breach made in 1900 in the Colorado River Dam at Austin, Texas, by two sections of the dam, each about 250 feet long, being forced bodily about 60 feet down-stream, without the slightest overturning, leaving them almost parallel with their original position, drew the attention of the engineers to a very important point they had overlooked, viz.: that when a dam is founded on a porous, pervious foundation, or on rock that is badly fissured water gets under the base of the dam and exerts an upward pressure, that greatly reduces the stability of the structure and may cause its failure. Another masonry dam built at Austin, Pa., was destroyed in 1911, on account of upward pressure under its base. To avoid this danger, some engineers have recommended that in designing a masonry dam, an upward pressure due to the full head in the reservoir be assumed as acting under the base of the dam (see Trans. Am. Soc. C. E., Vol. 34, p. 493). Other engineers have assumed water pressure under the base of a dam varying from two-thirds of the total head in the reservoir at the up-stream face to nothing at the down-stream toe of the dam.

Numerous fine masonry dams, designed without paying any attention to upward water pressure, have been standing successfully for many years. What conclusion shall we reach, then, as regards the necessity of including upward water pressure in designing a masonry dam? It all depends upon the nature of the foundation upon which the dam is to be built. If it consists of pervious, badly fissured rock, some allowance for upward pressure should be made in designing the profile of the dam, but it will be rarely, if ever, necessary to go to the extreme of assuming full water pressure under the whole base of a dam. Such a pressure might be reached at seams and fissures in the rock, but in most cases such seams would cover only a small percentage of the total area of the base of the dam. For this reason the late Alphonse Fteley, Past Pres. Am. Soc. C. E., left upward pressure out of consideration in designing the profile of the New Croton Dam, a masonry structure, 297 feet high above its lowest foundation (Fig. 7). In this case, the dam was founded on gneiss rock and limestone, which are more or less fissured in places. Mr. Fteley designed several other masonry dams for the city of New York, without taking upward pressure into account. The rock on which they were founded is gneiss or bastard granite.



Figs. 3, 4, 5 and 6.—Distributions of Pressure.

Contrasting Profiles and Reasons Therefor.—In contrast with the bold profiles for masonry dams, designed by Mr. Fteley, we have the much thicker profiles adopted for the Wachusett Dam of the Boston Water Works and of a number of dams, built since 1905 for the New York Water Works. Why this marked difference in the profiles of dams constructed for the water works of the same city? The late Fred P. Stearns, Past Pres. Am. Soc. C. E., who was the Chief Engineer of the Boston Water Works, when the Wachusett Dam, which is 205 feet high above the foundation, was designed and built, informed the author of this paper, that the city of Clinton, having a population of about 13,000, was located about half a mile below the Wachusett Dam, and that great apprehensions were felt by the inhabitants of said city about the danger to which they were exposed by the construction of a high dam a short distance up-stream from their city. In order to allay these fears, Mr. Stearns made the Wachusett Dam unusually strong, by giving it sufficient stability to resist, in addition to the water pressure against its up-stream face, an upward pressure under its base, assumed to be equal to the full head in the reservoir, when full, for the width of the cut-off wall, where it was then assumed to be reduced to two-thirds of the full head and to diminish uniformly to nothing at the front toe of the dam. In addition to this large upward pressure, Mr. Stearns included, also, an ice pressure of 47,000 lbs. per lineal foot, at normal water level in the reservoir to be acting on the dam.

Ice Pressure.—Some of the engineers who assisted Mr. Stearns in the preparation of the plans for the Wachusett Dam entered later the service of the city of New York, and so it is not surprising to find that in designing the Cross River, Croton Falls, Olive Bridge and Kensico Dams, they followed closely the principles they had used for the Wachusett Dam, taking ice pressure and upward pressure into account. In our present state of knowledge, the pressure which a sheet of ice, which expanding, might exert against a masonry dam, is unknown and the values adopted by engineers for this force are not based upon facts, but are simply assumption. In the design of the profiles of the Wachusett Dam of the Boston Water Works as already stated the ice pressure was assumed to be 47,000 lbs. per lineal foot at the normal water line. For the Cross River Dam and Croton Falls Dam of the New York Water Works the ice pressure was assumed to be, respectively, 24,000 and 30,000 lbs. per lineal foot at the normal water level. Unless the configuration of the ground is such that the sheet of ice in the reservoir can butt against some solid object, such as a wall, situated a short distance from the dam, it would seem that the sheet of ice would buckle before it would exert a pressure of 24,000 and 47,000 lbs. per lineal foot. The banks of most reservoirs are sloping, so that the sheet of ice could shove up on the banks, if it were subjected to any great pressure. For these reasons Mr. Fteley made no allowance for ice pressure in designing the New Croton Dam.

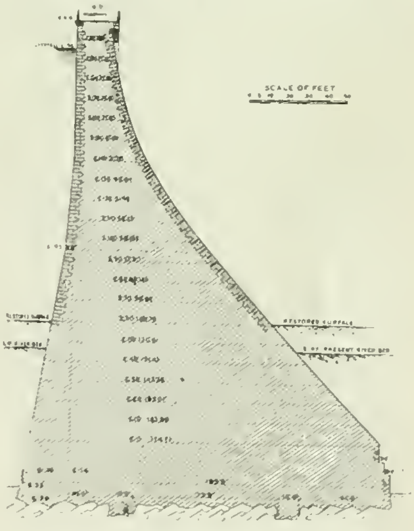


Fig. 7.—New Croton Dam, New York Water Supply—Built 1895-1907.

As far as the author knows, there is only one case on record in which ice pressure caused the final failure of a dam. The dam to which he refers was built in 1893-94 by the Minneapolis Mill Company of ashlar masonry, to form a pond for supplying power. This wall was 535 feet long, 18 feet high, 5¼ feet thick at the crest, and 12 feet wide at the base. A retaining wall, parallel with and 350 feet distant from the dam, forms the opposite side of the pond. During the week, the pond is usually drawn down two or more feet to meet the demands of power, but on Sundays it rises to its normal level. In winter the ice, over the central parts of the pond follows this motion, but at the dam and the retaining wall, the ice adheres to the masonry. Cracks caused by this unequal motion of the ice sheet are soon closed by expansion or freezing. Considering the thickness of the ice and the pressure caused by its unequal movement on Sundays, the Minneapolis Dam is certainly exposed to an unusual ice pressure. The dam stood successfully until the spring of 1899. In February of that year, when the temperature was very low, it was noticed that the down-stream edge of the coping was three inches lower than its normal position. This was found to be caused by a slight motion of revolution of the dam about an axis near its down-stream toe, caused by the ice pressure. The top of the dam was turned 10-12 inches down-stream, but no sliding occurred, and no crack or leaks were discovered. The ice was cut along the dam, which settled slowly about half-way back to its original position. To prevent a repetition of this motion, 4-inch holes were drilled, 25 feet apart, through the dam and 4 feet deep into the bed-rock. Three-inch steel anchor bolts were placed in these holes and grouted in.

On April 30, 1899, when two inches of water were passing over the waste weir of the dam, a section of the dam, 170 feet long, at the waste weir, slid out, the anchor bolts snapping like pipe stems. The failure of the dam is supposed to have been caused by water getting under the dam in some cracks or seams that were opened when the dam was slightly moved in the preceding February. The dam was immediately rebuilt with a stronger cross-section, and no further trouble has been experienced.

In this case, however, the conditions were different than those usually encountered. The sheet of ice was unusually thick, and not very long. Moreover, it abutted at each end against rigid masonry, and not against a sloping shore at one end, as usually is the case. The manner in which the ice in the center of the pond sank during the week and rose again on Sundays, while the ice at the dam and retaining wall adhered to the masonry caused a kind of toggle joint action in the sheet of ice, which probably increased the pressure it exerted against the dam.

We have considered now all the forces to which a masonry dam may be exposed, viz.: water pressure on its up-stream side, and in the case of a pervious foundation, also, to some extent under its base; the pressure caused by the weight of the masonry and in northern latitudes, the pressure resultant from the expansion of a sheet of ice, abutting against the dam.

(End of Part I.)

Topographic and Subsurface Draftsman, Grade A.—The U. S. Civil Service Commission announces an open competitive examination for topographic and subsurface draftsman, Grade A. A vacancy in the Public Works Department, Navy Yard, New York, N. Y., at $6.80 per diem, and vacancies in positions requiring simluar qualifications throughout the United States.

Shallow Wells as Source of Municipal Supply

Principles of Location and Construction and Examples of Municipal Shallow Wells Discussed in Paper Presented Nov. 2 at Annual Meeting of Iowa Section of American Water Works Association.

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A shallow well is usually defined as one whose depth is less than 100 ft. This is not a rigid distinction but it serves fairly well for our purpose. Wells of this class may be either open (dug) or tubular (driven or bored). Open or dug wells very rarely exceed 50 ft. in depth. Bored or drilled wells may be of varying depths within the limits mentioned. Both types are frequently used in developing municipal water supplies.

Open wells are of much larger diameter than the tubular well. One of the advantages of this type is that the well forms a storage reservoir for a considerable amount of water, for example, a well 12 ft. in diameter and piercing the water bearing stratum to a depth of 30 ft. has a storage capacity of a little more than 25,000 gal. When the pumps are operated at a variable rate the storage capacity tends to increase the real capacity of the well. Further in the operations of the pumps there are a number of advantages in being able to draw the entire supply from a single large well rather than from a number of small ones. If it becomes necessary to lower the pumps the large well permits the use of more economical pumping machinery. While the yield from a well of comparatively large diameter is somewhat greater than that which can be obtained from the small bore well, yet it does not increase directly with the diameter. Roughly, a well 10 ft. in diameter will yield 125 per cent more than a 6-in. well under the same conditions.

Tubular wells are generally driven into the water bearing stratum. They are of small bore, seldom exceeding 12 in. Because of the small diameter which limits the storage volume, as well as the small area through which water flows into the well, the velocity of the inflowing water is considerably higher than that of water entering a large well which furnishes the same amount of water. This higher velocity tends to move particles of sand toward the well and causes trouble by clogging. Special strainers are used in tubular wells to prevent the entrance of sand. The cost of construction of tubular wells is less per unit of yield than for dug wells. In fact, it may be cheaper to put down several small diameter wells connected with the same suction line than it is to build the larger well. Economy in construction is the advantage which tubular wells have over open wells, while difficulty in operation constitutes the disadvantages.

Location of Wells.—To furnish the large quantity of water needed for a municipal water supply a shallow well must reach a large and relatively porous water bearing formation. Wells of this type are not often found piercing a rock stratum except in limestone country where underground streams are sometimes tapped). Strata of sand and gravel having large areas furnish the most uniform and constant sources of the underground water which can be reached by shallow wells. The finer sands and clay formations are not satisfactory because of their lower porosity and the resulting frictional resistance to the movement of water through them.

The water table or surface of the underground water at any place is quite dependent on the topography. In a country that is rough, cut up into many hills and valleys by drainage channels, the water table will be at some distance below the ground surface on the high lands and much nearer to the ground level in the lowlands. In localities which are old from a geological point of view where the drainage lines are relatively stable we often find extensive deposits of water bearing material in the valleys which will furnish large quantities of water when tapped by shallow wells. In general, the water table has a surface which conforms with that of the ground surface but with more gentle slopes.

Shallow wells, then, should be located on low lands if they are to furnish considerable quantities of water and at points where a good water bearing formation of considerable area can be pierced without going to great depths.

But the quantity of water to be obtained is not the only requisite necessary. The well should be so located that it will furnish a water of satisfactory quality. It should be removed from all possible sources of contamination. Some judgment will be needed in obtaining a satisfactory location, for not only must present conditions be considered but thought must be given to the possible conditions which may arise as the town or city grows. Shallow wells should be developed out of the path of the natural drainage lines from the municipality. It is far better to locate wells of this type at some distance to one side of the main drainage axis of the city than it is to put them along this axis even though at the time of development the distance from possible sources of contaminations seems to be a very safe one. The writer has observed many instances where the municipality has grown toward the waterworks plant and as a result the quality of the water has become less safe year by year until finally the wells have been abandoned.

Construction of Shallow Wells.—Shallow wells should be so constructed that surface water cannot get into them. The curb on open wells should be water tight to a depth of 10 or 12 ft. and should extend above the ground surface so that the grading around the well will slope away in all directions. It is good practice to provide housing over large open wells. Tubular wells have the watertight casing and should be given the same surface protection that has been mentioned for open wells. The practice of partially digging a shallow well and then driving tubular wells in the bottom of the well has certain advantages in increasing the yield at less cost than would be incurred if the well were dug for the entire depth. The principal advantage is that the pumps may be lowered. The construction of manholes around the tops of tubular well for the purpose of protecting the well-head from frost action should be carefully planned so that surface water will not collect in the manhole and overflow into the well. The writer recalls one development where the well casing projected only a few inches above the bottom of the manhole. The suction pipe was smaller than the well casing so that there was an open annular space through which surface drainage could flow over the edge of the casing into the well. As the manhole did not extend above the surface of the ground surface wash did enter. The importance of protecting wells from surface contamination cannot be too strongly emphasized.

With these points in mind let us consider briefly some actual instances of municipal water supplies which are obtained from shallow wells. These installations have been chosen not because they exemplify good practice but rather because in each case there is a lesson for those concerned with shallow wells and, after all, we may learn more from failures or partial failures than we do from successes.

Examples of Municipal Shallow Wells.—A city of 2,000 population obtained its public water supply from five dug wells which were located on low ground within one block of the business district. These wells were of the dug type. One of them was located at the side of the main business street and protected by a cracked concrete cover, another was within 15 ft. of an artificial pond which received considerable street drainage in wet weather, the other three were in a vacant lot which was considerably lower than the adjacent land. In every instance it was possible for surface drainage to enter the well. Each well was connected with a sump well at the pump house to which water flowed by gravity. The quality of the water was bad and the quantity insufficient to supply the needs of the city.

This installation is an example of poor location in the first place with the lack of proper protection from surface drainage adding to the hazard. Yet this community tolerated such a condition of affairs for many years. During the last few years the fact that the city water was not safe to drink was recognized and freely admitted by the citizens. It was used only for flushing and fire purposes. This meant that in many houses there were three sources of water supply, the publis system for bath rooms, a cistern to collect rain water for laundry purposes and a private well which was the source of drinking water. It is not difficult to imagine that with three sources of water supply in the house a mistake might easily occur. About a year ago the well system was abandoned. The present supply is obtained by filtration of a surface water.

A town of 900 population, located very near the drainage line between the Missouri and Mississippi Rivers, is built around a public square. About six years ago the citizens decided to build a public water supply system. Since shallow wells had furnished plenty of water at private houses it was thought that all that was necessary to secure a satisfactory supply for the proposed public system was to dig a large well. Evidently the only consideration given to the location was that it should be as close to the center of the town as possible so that the problem of distribution might be simplified and the expense of constructing the system be kept at a minimum, for the well, pumping plant and elevated tank were built within a half block of the public square. The well is 12 ft. in diameter and 40 ft. deep. There is no sewerage system in the town—open-pit privies are used. With several of these unsanitary affairs within 50 ft. of the well is it any wonder that the water was pronounced unsafe and the well condemned by the State Board of Health?

In this particular case the surface protection of the well was fairly good, but the impossibility of obtaining a satisfactory public water supply from a well in this privy-infested location would have been immediately recognized by any experienced waterworks man. The town in question is still wrestling with its water supply problem and judging from its further unfortunate experience with a deep well 375 ft. which furnishes a limited quantity of a highly mineralized water it has not yet realized the value of obtaining competent advice.

Gradual Contamination of Well.—The experience of a third town illustrates the point that a shallow well which has furnished a satisfactory supply of water for a public system may gradually become contaminated as the distribution system is extended. This is a case where the distribution system has been extended into a residential section which is not sewered. The result is that the underground water is receiving a contamination from cesspools that is increasing in volume every year.

The town in question has a population of 1,400 and is divided by a river. The business district and larger residential district are located on the east side of the river while a smaller residential district containing about one-third of the total population is on the west side. As is often the case the river has a broad alluvium plain which is underlain by a sand and gravel formation of considerable area and depth. This is an excellent water bearing formation—the underground water flowing toward the river. The city well, which is 18 ft. in diameter and 24 ft. deep, is located on the west bank about 75 ft. from the stream. The general direction of ground water flow is southeast. There are now 10 cesspools within two blocks—the nearest being about 250 ft. from the well, in the territory northwest of the plant. While bacteriological pollution has not appeared, the chemical composition of the well water as determined by the examinations which have been made during the last eight years, shows evidences of the increasing pollution of the ground water which comes to the well. It seems quite probable that the water from this source will soon become unsafe if the pollution of the ground water is allowed to continue. The use of modern plumbing in the homes, made possible by a public water supply system, bids fair to become a boomerang in this city unless provision for the removal of waste water is made.

Interesting Example of Well Installation.—One of the most interesting examples of shallow wells as sources of municipal water supply was that which was found during the course of a sanitary survey made by the writer a few months ago. A town of some 900 population is located on the northern slope of a broad river valley. The business district is on low ground about ¾ mile from the river. The residential sections are on the slopes which rise gradually from the center of the town toward the north and east so that the main drainage axis of the town for both surface and ground water runs south from the business district. The town waterworks plant is located on this axis and in the first block south of the commercial center.

Water is obtained from six driven wells 6 in. in diameter spaced approximately 3 ft. apart. These wells are located in the basement of the city hall which was evidently built over the waterworks plant. The wells are cased with 6-in. galvanized iron pipe. A 3-in. suction pipe from each well is connected with the main suction pipe of the pump. The casing projects about 3 in. above the concrete floor of the basement. There is an annular opening between well casing and the suction pipe at each well-head. This is covered by a loose tin cap which possibly serves to keep out dirt, but is not water-tight. The basement in which the wells, pumps and pneumatic tanks are located was drained through a tile pipe which discharged into a ditch about 100 ft. back of the building. The difference in elevation between the basement floor and the outlet of this drain was about 18 in. No check valve was provided on this drainage line.

An unusually large rainfall early last spring flooded the ditch into which the drain discharged and caused surface water to flow back through the drainage line, flooding the basement to a depth sufficient to submerge the tops of the wells. Fortunately the town officials recognized the seriousness of the situation and after issuing a warning to the public that the city water was unsafe, took immediate steps to clean out the wells, disinfect the entire system and fix the drainage system so that flooding of the wells might be prevented in the future. This is an example of a shallow well development in which the protection of the wells from surface contamination would appear to the casual observer to be entirely adequate but where a careful examination of the situation would show its inadequacy.

Danger of Locating Wells on Main Drainage Axis.—This same development will serve to illustrate the danger of locating shallow wells on the main drainage axis of the town. Until this past year cesspools and privies have been the only means of disposing of sewage. (A sewerage system and sewage disposal plant were constructed in 1921 and put into service early in 1922.) There is very heavy contamination of the underground waters within two blocks north of the well. That this contamination affects the municipal wells is shown very closely in the results of the few examinations that have been made during the last four years. In 1918 laboratory examinations of a sample of water from the municipal supply showed the following chemical composition: Nitrites .000, nitrates 25.0, and chlorine 72.0 parts per million. On a sample analyzed in June, 1922, the results obtained were as follows: Nitrites .008, nitrates 30.0 and chlorine 98.5 parts per million. These examinations, while too few to give conclusive evidence, certainly indicate gradually increasing contamination.

During the sanitary survey samples of water were also taken from private wells in different sections of the town. The results of laboratory examinations of these samples showed the influence of the density of population in the vicinity of the wells. Water from wells located near the center of the town gave results on chemical examination almost identical with those on water from the municipal wells. The following table gives results on well waters in different sections of the town.

RESULTS OF CHEMICAL EXAMINATIONS OF WELL WATERS IN X.

	Chemical results p. p. m.		
Well.	Nitrites.	Nitrates.	Chlorine.
A	.016	20.0	71.5
B	.700	10.0	121.2
C	.001	0.2	3.0
D	.000	0.1	5.0

"A"—Municipal well on main drainage axis.

"B"—Private well on main drainage axis below "A."

"C"—Private well near western edge of town.

"D"—Private well near eastern edge of town.

It will be noted that well "B" shows results even more unsatisfactory than those obtained from well "A" while the results from examination of water from wells "C" and "D" show that the ground water at points located at some distance from the main drainage axis is of much better sanitary quality.

Methods and Costs of Myers-Whaley Shovel Operation in Waterworks Tunnels

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Data From Hetch Hetchy and Shandaken Tunnels and Comparisons With Hand Mucking.

It has long been recognized that removal of the muck exerts a very important influence upon the speed at which a tunnel can be driven. Brunton & Davis, in their book on "Modern Tunneling," page 260, call attention to this fact. They state that where the vertical column, or the drill carriage, is employed the remainder of the work cannot proceed until the heading is cleared, and that every minute saved at this work can be transmuted directly into progress. With the horizontal bar system of drill mounting, the mucking can be done, to a large extent, simultaneously with the drilling, but if the muck is not cleared out by the time the upper round of holes is drilled the delay is serious. It is essential for rapid progress, in any event, that the muck be removed as speedily as possible.

Hand Mucking.—The space in the tunnel heading is most restricted, and only a limited number of men can be used for hand mucking. A larger number merely crowds the space and impedes the work. Considerable thought and space in Brunton & Davis' book has been given to the best method of using hand muckers. At the time this book was written (1914), mucking machines were almost unknown, although on pages 170, 171 and 172, mention is made of them, and the Myers-Whaley shovel used under New York City in the Catskill Aqueduct in 1913 is illustrated and described.

There is a reference to the Laramie-Poudre tunnel, where it is stated an excellent method of hand mucking was developed—six muckers being employed and cars of 16 cu. ft. capacity were filled ordinarily in three or four minutes' time. It was then necessary to shift this small car out and another one in.

It is stated that in the Loetschberg tunnel five minutes were required to fill a car holding 35½ cu. ft. by a crew of 10 men, with an extra minute to remove it when full and replace it with an empty one. According to these figures the men averaged between 0.67 and 0.89 cu. ft. per minute each in the Laramie-Poudre tunnel and 0.71 cu. ft. per minute in the Loetschberg tunnel. It might, therefore, be taken that with hand mucking, and during the time that a car was actually placed at the face, such cars would be loaded at the rate of 0.65 to 0.9 cu. ft. of muck per minute per man mucking.

Car Types and Operation.—The handling of cars to the heading is a very important item, both in hand mucking and in machine mucking. In hand mucking, however, small cars are found to be easier to load as they do not occupy so much space and there is more room for the shovelers to work. They are also easier to replace in case of derailment. It is obvious, however, that more of them have to be used. In machine mucking the car should be as large as can be conveniently handled in order to reduce the ratio of time lost during the shifting of the cars to the time that the cars are at the heading ready to be loaded. Passing switches for empties and loads should be placed as near the heading as possible.

Steel Sheets for Shoveling.—Steel sheets have been used with satisfaction at tunnel headings for the men to shovel from. They furnish a smooth floor upon which the hand mucker can push his shovel very much easier than he can when he has to push it into the pile of rock or along the rough bottom. It is stated in this book on tunneling that experience in a large majority of tunnels leads to the conclusion that steel plates for shoveling when hand mucking is used are among the chief economies. They are not required for machine mucking.

Introduction of Machine Mucking.—Tunnel engineers and contractors have recognized for many years that hand mucking should be superseded by mechanical mucking and in large tunnels where the boom could be swung steam shovels have been used. In smaller tunnels, say, less than 20 ft. in width, a different type of machine becomes necessary.

The Myers-Whaley machine was designed for mining work primarily, and during the past 10 years it has been developed, strengthened and employed in handling the hardest kinds of rock, such as magnetic iron ore, limestone, rock salt, lead ore, shale, etc.

These shovels were first used in water tunnel work by the Holbrook, Cabot & Rollins Corp. of New York City, in their contract on a section of the Catskill Aqueduct under New York City in 1913.

The Hetch Hetchy Tunnel Job.—The next tunnel of importance employing these machines was the Hetch Hetchy tunnel for the San Francisco Water Supply.

The mountain division of this tunnel is approximately 18½ miles long and consists of two tunnels, one about 13 miles long and one about 5½ miles long of continuous excavation. The cross section varies from 11 ft. 3 in. in width and height, as at the Priest Portal, to 13 ft. 8 in. at the intake.

Thirteen Myers-Whaley shovels are now employed on this tunnel. The first one was installed in August, 1918, the second and third machines in September, 1919, and a fourth in August, 1920. Nine additional machines were purchased in December, 1920, and installed during the succeeding four or five months. A smaller type of mucking machine, the Hoar underground shoveler, is installed at the Big Creek shaft, where the opening was insufficient to permit the entry of the larger parts of the Myers-Whaley machines.

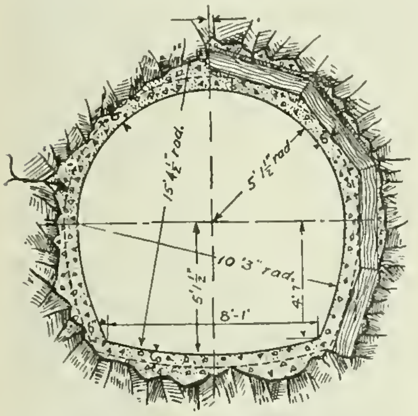
The work of these machines can best be judged by data as follows: In the Annual Report of the Bureau of Engineering, city of San Francisco, for the year ending June 30, 1920, the following information is given:

"Priest Portal—A progress of 2,915 ft. was made in this heading in a formation of slate, quartzite and mica schist that at times required timbering. A Myers-Whaley shoveling machine was in continuous service and unquestionably accounts for the maximum progress with a minimum cost for the work. The average cost per lineal foot exclusive of overhead and plant charge was $18.18 for labor and $9.28 for material."

On page 72 of the same report, under the heading of "Early Intake," appears the following:

"A progress of 1942 ft. was made in a granite formation. A Myers-Whaley shoveling machine was installed and has been in service since January 20. The efficiency of the mucking machine can be shown by the following comparison: In December, 1919, with hand mucking a progress of 188 ft. was made at a cost of $26.19 per lineal foot for labor and $10.79 for material. In February, 1920, with the mucker in service a progress of 250 ft. was made at a cost of $20.17 for labor and $11.43 for material."

The representative of the Myers-Whaley Co., who installed the last nine machines, made a detailed report on the work at the different headings in 1921. In one of these headings it was possible to make a comparative record of the number of men employed and the labor cost of mucking by hand, and also, as the machine was installed shortly after that time, to get the exact labor cost of machine mucking. The report was as follows:



Standard Section of Hetch Hetchy Tunnel, San Francisco Water Supply.

"Tunnel section nearly round, approximately 11 ft. 6 in. rough diameter.

"Time required to drill a round (full tunnel section) and shoot, 14 to 16 hours. Cut pulls from 9 to 13 ft. The drilling is done in two shifts with 3 drill men, 3 chuck tenders, 2 steel nippers and 1 shift boss for each shift.

"The length of steel used is 13 ft. and the heading is drilled with a V-shaped cut, with 24 to 27 holes to a heading. The distance in from portal was 600 ft. on Feb. 18, 1921.

"In mucking by hand before the machine was installed, 3 shifts of muckers were used and on each shift were six men at $5 per 8 hours each, and one muck boss at $6.50, and the time required to muck out the full shot was from 19 to 21 hours. The cost of same for the three shifts was:

18 muckers at $5 each	$ 90.00
3 muck bosses at $6.50 each	19.50
Total labor for mucking a round	$109.50

"After the machine was installed and with the same drilling, the following observations were made:

"Time required for loading out the shot from 3 to 5 hours, depending on the promptness with which the muck cars were handled.

"The cost for mucking, men being paid for a full shift although the shot was loaded out in one-half shift:

1 operator	$ 7.00
2 men in front, at $5 each	10.00
2 men on the car at $5 each	10.00
1 muck boss	6.00
Total labor cost for mucking out the round with the machine	$33.00

(Note—The muck boss is not an essential man and could be dispensed with in machine mucking.)

"Time required for loading each car with the machine, 1½ to 2 minutes per car. Time required to shift cars, 1½ minutes per car."

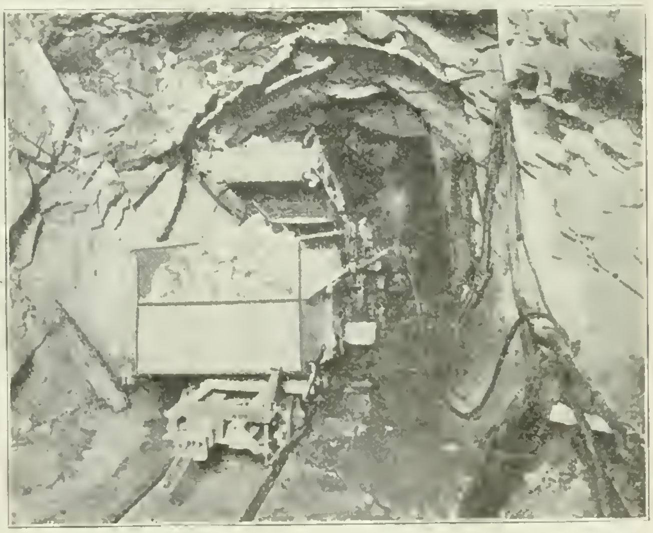
The cars were side dump cars, holding approximately 1½ yd. of loose muck each.

Comparing the above operations, it will be seen that the net saving in cost of labor per shot was $76.50. The net saving in time of mucking per shot was 16 hours. If the average shot pulled 11 ft. of tunnel, the average saving in cost of labor for mucking alone would be nearly $7 per foot of tunnel.

The net saving in time is as important as the direct saving in cost, as the saving in time speeds up the entire job and every day saved means a tremendous amount in reduction of over-head charges.

That the speedier removal of the muck has a very appreciable effect upon the speed of driving the tunnel may be illustrated by the following quotation from Mining & Scientific Press, Sept. 24, 1921, in a letter from Mr. F. C. Hickman, in charge of the Priest Portal of the Hetch Hetchy tunnel:

"I established what I think is a new United States record for hard rock tunnel driving last month, namely, 776 ft. in schist and quartzite. The work was done at Priest Portal, which is a part of the Hetch Hetchy project on the mountain division. Dimensions 11 ft. 3 in. Area of heading 106 sq. ft. An average of 28.3 lb. of 40 per cent gelatine powder was used per foot. Ingersoll-Rand Leyner machines were used, three machines on the bar, and the Myers-Whaley mucking machines were used. Worked three shifts per day, and during the month 38 hours were lost on account of repairs and power failures."



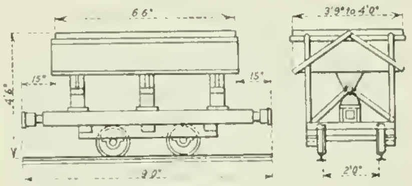
Myers-Whaley Shovel Loading Muck Car in Hetch Hetchy Tunnel.

Further information of interest in regard to the Hetch Hetchy tunnel is as follows:

Water-Leyner, Sullivan and Waugh rock drills are used. Storage battery locomotives are employed for handling side dump muck cars operating on 30-lb. rail, 24-in. gage. Power for the mucking machines is 60 cycle, 3 phase, 220 volt and each machine is driven by a 20 HP. motor.

That mechanical mucking has proved satisfactory on the Hetch Hetchy tunnel is conclusively shown by the act of the Bureau of Engineering in equipping the tunnel throughout with these machines after first having thoroughly tried them for an extended period.

The Shandaken Tunnel.—The Shandaken Tunnel, which is a part of the extension of the Catskill water supply for the city of New York, is over 18 miles long, and is one continuous excavation. Its cross section is approximately the same as that of the Hetch Hetchy. Muck cars holding 47 cu. ft. are employed and are handled by storage battery locomotives. The track gage is 30 in. Power for mucking machines is 60 cycle, 3 phase, 220 volt. The tunnel is attacked by means of eight shafts and one portal, located as shown on the profile. Only six shafts have been operated, however, as the Intake Shaft and Shaft No. 2 have not been equipped for hoisting.



Type of Car Used in Hetch Hetchy Tunnel.

The work is being done by the Ulen Contracting Corporation, Allaben, N. Y., Mr. Thomas S. Shepperd, vice president, in charge. The Ulen Co. succeeded the Degnon Contracting Co. of New York, who had the original contract and started the work.

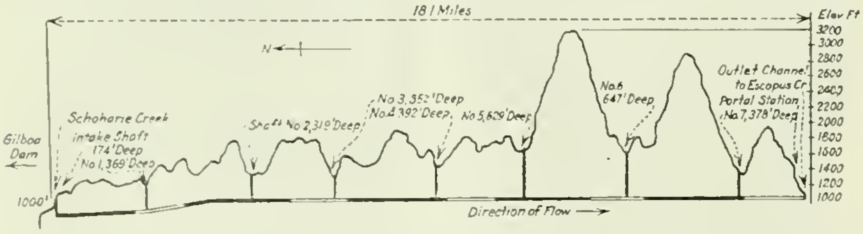
The first mucking machine on this work was installed in February, 1919, and three additional machines were installed two months later. These machines have been in continuous operation on the Shandaken tunnel since that time and this work, like that at Hetch Hetchy, has been driven in record time.

The Myers-Whaley shovels in the Shandaken tunnel each average approximately 60 cars per shift, cars being of 47 cu. ft. capacity and the muck weighing about 115 lb. per cubic foot. The machine is actually operated about four hours per shift, including the delays incidental to spotting cars, advancing tracks, etc. The actual loading time is about 2 minutes per car. Total cost of loading, including all costs of advancing tract, moving machine into the heading, backing out, and the labor on repairs, averages about 35 ct. per cubic yard, which is one-third the cost of mucking by hand.

On analyzing the time of loading in

the Shandaken tunnel it will noted that 2,820 cu. ft. of muck are handled in an elapsed time of 4 hours, or at an average rate of 11¾ cu. ft. of muck per minute, including the time required for track laying, car shifting, etc. The average rate of loading only is 23.5 cu. ft. per minute. On the basis of a man averaging 0.7 cu. ft. per minute the machine is equivalent to 33 man power.

In the hand mucked headings of the Shandaken tunnel the heading and bench method is employed, and as a rule 18 men per shift are used for mucking (the number running from 14 to 21, depending upon the length of the shot pulled and the amount of muck to be handled). The heading muck is handled in wheelbarrows over a scaffold and runway from the bench, into cars, and it is generally figured that the amount of muck should equal about 150 cu. ft. per man per shift (8 hours), counting the muck foreman, wheelbarrow men and all men employed on the muck pile and allowing for all time lost waiting for trains, spotting cars, setting up and taking down scaffolds. data presented above, attention is runways, etc.



Profile of Shandaken Tunnel, New York City Water Supply.

Summary.—On summing up the called to the following important features in connection with the use of shoveling machines:

First: Speed, for the quick removal of the muck means that all of the other operations can be speeded up and the job completed earlier, thus cutting down overhead and carrying charges.

Second: Smaller number of men required at the operation. We have seen that it required 18 to 21 men to muck out a round by hand which is handled by 5 or 6 men with the machine. This means that quarters in a rough country (where tunnels are usually driven) have to be provided for less than one-third as many men so far as the mucking is concerned. That the cost of bringing men in, and the labor turnover, can be very much reduced. In times of labor scarcity higher wages can be paid the men employed and a dependable force kept always on hand. The securing of ordinary labor for hand mucking has always been a troublesome problem for the superintendent of construction.

Third: The actual cost of mucking. On any job it is difficult to define clearly what collateral benefits can be secured by improvement of any one feature of the work, for they are inter-related and influence each other. However, the cost of performing one function can be reached, and in this case it can readily be shown that the labor cost of mucking with machines per yard of muck handled is approximately one-third of the labor cost of mucking by hand. On most tunnel jobs the contractor will figure on charging off his machine against the job, and the amount to be charged per yard will depend on the gross yardage to be handled. He will still have left a large part of the cost of hand mucking as a direct saving or profit as compared with hand mucking. His machines must have been kept in good shape in order to perform their functions, and they have a re-sale value at the end of the job.

Myers-Whaley shovels are adapted to the loading of coarse or fine rock of any character, provided it is shot loose and the pieces are not larger than 28 in. in any one dimension. There is a maker's guarantee that the machine will work in such material at an average rate of one ton per minute of actual operation.

Myers-Whaley Shovel in Shandaken Tunnel.

Methods of Promoting and Selling a Waterworks Bond Issue.

BY J. W. McAMIS.
Superintendent of Waterworks, Greeneville, Tenn.

We have recently held an election for bonds to make extensions and improvements in the water and sewer systems of this city, and were so successful in carrying the election by a majority of about 3½ to 1, that I believe the methods used in promoting this bond issue will be of interest to many of your readers.

About a year ago the same proposition was submitted to the voters and lost by a small majority. It was the opinion of the writer, the city clerk and the city engineer that the issue was lost because too small a number of citizens were qualified to vote, and we used our influence with the board of aldermen to have the election called immediately following the regular county election, depending on the politicians to see that the voters were qualified to vote in the county elections.

We then did all the usual things in such cases—we took all the space we could get in the one daily paper. The city engineer and the writer made talks before the civic organizations wherever we could get dates, made maps, showing the locations of the improvements, etc. But the real work was done by personal contact, we hunted up the man whose property was to benefit by the new sewers and water mains and said to him, "now this improvement will be worth good money to you in the improvement of your locality and if you want it you must get out and do some work."

In this way we got plenty of workers, that is we got next to the man who wanted something, and pushed him out to do the work. We divided the city into districts by streets and blocks, giving each worker just enough territory so that he could see every voter in his district and still not overwork him, or her for there were several public spirited women who did good work.

We proceeded on the assumption that there were plenty of voters in favor of the improvements if we could get them to the poles, and told the workers not to spend their time trying to convince some crank, but to find those who were for the bonds and then be sure that they voted.

The result of the voting showed that we had the situation sized up about right. I believe there are always enough public spirited people to carry such things through if they can be gotten out to vote.

We provided a clerk at each polling place to record the name of each person as they voted and each worker could tell at a glance whether all those for whom he was responsible had voted or not. He was then in position to go after those who were hanging back. Each political party had lists of the qualified voters made for the county election, and these lists were borrowed and used to good advantage in selecting the persons to be seen.

We used the boy scouts to drive cars, and run errands and they were a great deal of help. After the election we were then provided with another job just as hard, that of getting a good price for the bonds. The city clerk wrote all the bond houses that had ever bought any of our bonds, and several other good houses, a personal letter telling the date of the sale, the terms, the assessed valuation, the amount of bonds outstanding and all information needed to make an intelligent bid. The result was that eight first class bond houses were represented in person, on the day of the sale.

It was understood before hand that if the bids should prove to be unsatisfactory to the board, the bonds would be auctioned. The bids were opened, and the auction sale was held at once. The issue of $125,000, brought $1,000 premium at an interest rate of 5¼ percent, the purchaser bearing all expense of printing the bonds, legal opinion, etc. and paying the accrued interest at the time the bonds were issued. It should be remembered that Greeneville is a small place of 5,000 inhabitants and not very widely known and here-to-fore it bas been a problem to sell bonds at par at 6 percent.

The Management of Municipal Water Works

Broader Aspects, Particularly the Policies Which Underlie Good Service Discussed in Paper Presented Nov. 1 at Annual Meeting of Iowa Section of American Water Works Association.

By CHAS. B. BURDICK,
Of Alvord, Burdick & Howson, Consulting Engineers, Chicago, Ill.

The average American city doubles in population about once in 23 years. It is not financially practicable nor would it be economical to build waterworks capable of supplying indefinite future needs in the average city. The investment would be too large, and it would throw the burden too heavily upon the present water takers. It is better policy to build for the near future on a well-defined plan capable of indefinite expansion if possible. It is important that expenditures for betterments be carried out well in advance of need; for a deficiency in the water supply is likely to lead to heavy losses from fire, or in an industrial city, a serious water shortage may produce serious losses to manufacturers and wage earners, and if it is persistent may hamper the growth of the city.

Good management, therefore, requires that the available revenues of the property should be proportioned to a well defined program of construction. It is believed that this is the most important phase in waterworks management. More plants fail in good service today through inability to finance needed improvements than from any other cause. This condition usually arises from a failure to look sufficiently far into the future, or to provide funds a little in advance of need.

A Program of Improvement.—While it is not practicable to build works for an indefinite future, it is perfectly practicable, however, to forecast with reasonable accuracy service requirements and to lay down on paper the improvements that probably will be needed over a generation or more, with estimates of cost. It is practicable to forecast the most probable growth of the city, the amount of water to be pumped, the area that must be supplied, and the size of the main pipes required for good service in fire protection now, 10 years from now, or 20 years from now. It is practicable to investigate the source of water supply and determine how far it can economically be developed, and what future additional sources of water supply are available, and which ones are likely to be developed with greatest economy under future requirements. When the future requirements of service have been determined, it is comparatively a simple matter to determine the number and size of engines and boilers, and the extent and direction of expenditures for housing them. The requirements for water storage can be forecasted with accuracy when the probable conditions of service are fixed, and the most feasible plans for water supply have been determined.

Thus to formulate a program it is not necessary that the waterworks manager should be gifted with second-sight. No magic is required in this matter for reasonably dependable forecasts. All that is required is that the program laid down shall be the best program possible in the light of past experience in the city in question, viewed in the light of experience in similar cities. When the best program has been determined it should be followed by proper investments a little in advance of need. No waterworks should work on a margin less than three to five years in advance of its service requirements. If it is working on a well defined program certain expenditures will necessarily be made further in advance, as in the purchase of lands or sometimes in constructing a portion of feeder mains.

It is not to be expected that the future can always be forecasted with accuracy. The program can and should be modified from year to year in the light of further experience. If the service requirements have been overestimated, improvements made will last somewhat longer than anticipated. If the service requirements have been under-estimated then the building program will necessarily be speeded up, but under adequate rates it is presumable that funds will be available more quickly if the rates have been adjusted to fit a program of growth.

In the absence of a well defined program, improvements must be hurriedly conceived, financed and carried out. This results in pumping stations abandoned, because they are no longer capable of expansion, feeder mains taken up, because they are too small, water supplies abandoned, because they are too close to town, or no longer capable of expansion. In short, it means wasted money. It is true that good economy sometimes dictates the temporary use of structures later to be abandoned. If this can be shown to good economy under the local circumstances, no fault can be found with it; but it should be done under a good program carefully considered.

A Growing Investment.—The latest available U. S. census statistics, which refer to prewar conditions, indicate that the average investment in municipal waterworks is $32.60 per capita of the cities supplied. This refers to 105 cities in the United States over 30,000 population, aggregating 19.6 million people. The average operating expense was $1.48 per capita. Allowing 6 per cent for interest on the investment, and 1 per cent for depreciation, the fixed charges would be $2.28, making the cost of water $3.76 per capita, including operation and fixed charges.

At the present time our works are operating upon a higher scale of prices, although somewhat lower than those obtaining two years ago. Cast iron pipe which is the largest item in waterworks construction, was worth about $25 per ton prewar at Chicago, $85 at the peak early in 1920, and about $49 at the present time, 100 per cent, 355 per cent and 200 per cent, respectively, as compared to the prewar basis. Common labor, using 1915 as the 100 per cent basis, increased to about 225 per cent upon the average, and has now receded to a little under 200 per cent. Other items entering into the cost of waterworks are, however, now upon a lower price basis, particularly construction costs which were very high and uncertain two years ago. Recent appraisals of several plants in detail indicate a total price basis approximating 160 per cent as compared to 100 per cent prewar. Applying this ratio to the census figures indicates that at the present time new waterworks construction costs not less than $52 per capita.

The review of operating expenses presented by Mr. Leonard Metcalf, C.E., in a paper before the American Waterworks Association, published in September, 1922, indicates that the per capita operating expenses probably approximate 175 per cent at this time as compared to a 100 per cent prewar base, and, therefore, probably approximate in the neighborhood of $2.60 per capita per annum. Seven per cent to cover interest and depreciation on $52 per capita investment is equivalent to $3.64, which added to present operating expenses makes the cost of water about $6.24 per captia, or approximately 170 per cent of the prewar figure.

On the present price basis, therefore, the average American city of 100,000 people must spend about $5,200,000 for new construction during the next 23 years. This is equivalent to about $225,000 per year. This expenditure will, of course, be more or less in individual cities, depending upon how fast they grow, how successfully they have looked ahead in planning the works already built, and the extent to which existing properties are necessarily abandoned. The city with the most successful building program will produce the cheapest water under ordinary circumstances.

Distribution of Cost.—When the probable service requirements of a city have been determined, and a building program has been laid down, it is then practicable to prepare an estimate of operating expenses, allowances for depreciation, and the annual sums that will be required for betterment. When this has been done, it is practicable to determine the probable cost of water from year to year, and it is possible to fix water rates that will operate the property, maintain it and finance the necessary improvements. A successful rate is one that maintains the property and equitably distributes the tax between those receiving service.

In the formulation of a system of rates, a reasonable period in the future should be considered, say, 10 to 15 years for rates not easily changed. In the light of the water works program the total sum to be derived can be determined. This sum should first be divided as between the public in general that receives fire protection, and the public and private water takers. A large part of the ordinary water works investment is necessitated by the requirements of fire protection. There is no reason why the public-at-large should not carry this investment. It also affects operating expenses in less degree. That part of the revenue to be derived from the water consumers should be distributed among the different classes of rate payers reasonably in proportion to services rendered, and if possible a rate should be fixed for very large users low enough to secure the business. This is impossible in some cases, for water cannot be continuously sold at a net loss, but it is sometimes practicable to supply the large consumers at less than the average cost of the water including all the fixed charges, and by so doing actually reduce the water bill of the small consumer.

Water Boards.—The management of a municipal water works directly through the city council or city commissioners has been extensively practiced, and in general, it has proved a failure. A permanent policy is just as necessary in a water works as in any private business. It should have a management as permanent as possible in public undertakings. No program can be laid down and successfully followed under periodic changes in management. Most city administrations change several times in a decade. Where council management has worked satisfactorily, you will usually find a water works superintendent big enough and capable enough to hold his job in the face of political upheaval. Usually, however, he must be somewhat of a politician to accomplish this.

It is believed that the best form of water works administration today for municipal plants is through a board of trustees with moderately long overlapping terms, so created and constituted, as to be removed from politics so far as possible.

At Des Moines, Ia., the plant is administered by five trustees appointed by the mayor and council, the terms are overlapping. The board at present consists of the president of an insurance company, the manager of a large department store, a coal operator, a former mayor, and a representative of union labor. The plant is operated in all respects the same as a high-grade private corporation. The expenditure of funds is entirely in the hands of the trustees. Bond issues must be approved by the city council. The works, however, will largely be financed out of revenues.

About 20 years ago the city of Burlington, Ia., inaugurated a water works administration in the acquirement of a private plant, that has operated very satisfactorily. A local corporation was formed which purchased the city water works from its former owners. The necessary capital was obtained by the sale of 4 per cent bonds and 6 per cent stock. The property is administered by five trustees, three appointed by the stockholders and two appointed by the city council. All profits above 6 per cent on stock go to the city and are to be applied in the purchase of stock. Ultimately the city will own a majority of the stock.

At Orlando, Fla., a new departure has been taken in the method of appointing the water works trustees. The mayor named as the water board the presidents of four local banks. It is planned to incorporate this automatic system of appointment in the state law, relating to this city and thus keep the water works out of politics permanently.

A continuing policy, a well considered program of betterment, and an adequate system of rates are the fundamentals of success in the water works business. Given these the manager can organize his executive duties, administer his property with economy, and go to bed at night with reasonable assurance of unbroken rest.

How to Get Right Kind of Publicity for Water Cos.

Method Employed by Terre Haute Water Works Co. Described in Paper Presented Nov. 2 at Annual Meeting of Iowa Section of American Water Works Association

By DOW H. GWINN,
President and Manager, Terre Haute (Ind.) Water Works Co.

Some operators take their publicity matter to the editor when they should see the advertising manager—they fail to distinguish the difference between news matter and that which belongs in the advertising columns. An operator who would resent the suggestion that he furnish service free of charge, should keep that idea in mind when he goes to the newspaper office with copy. A newspaper must charge for advertising matter. Therefore, when you wish to acquaint the public with facts about the waterworks business, see the advertising manager and make a contract for space.

The Newspaper Advertisement.—The average waterworks operator is better qualified to prepare copy about his business than the average advertising solicitor. Plenty of time should be taken in the preparation of copy. If a series of advertisements are to be used, it is advisable to start in with one of a historical character, a second with some of the difficulties of a practical character that had to be overcome; the third insertion could give a description of the present system—why it was used. Somewhere through the series, the name of the engineer or engineers should be given, the trouble in financing the enterprise, the names of those who bore the responsibility of getting the works started. Credit should be given where due. It is a mistake to try to tell too much in one issue of the paper. In most cases, 5 in., three columns wide, is sufficient space, with at least two insertions of each story or talk. Change copy weekly. Contract for space on the editorial page if it is used for advertisements. It is advisable to complete copy for the entire series before beginning publication.

The average man in the street and the woman in the home, do not know of the difficulties which must be overcome in securing and maintaining a good water supply. The relations with the public may be improved by informing the public about the water business, provided, of course, the water supply is good and the service satisfactory. The first essential in good publicity is good water, including satisfactory pressure, coupled with courteous treatment.

The public should be taken into the confidence of the waterworks operator; it is poor policy for the public to get the idea that the operator is covering up something. Let the public know what you are doing. If you contemplate important improvements, take space in the newspaper and state what you are about to do, who you have engaged to plan the work, the standing of the engineer and what he has done in other cities. If an application is to be made for an increase in rates, space should be bought for making the announcement and full particulars should be given so that the public will be able to judge as to the reasonableness of the claim for higher rates.

In furnishing information to the public, it is well to bear in mind that the large majority of people are honest and fair and are willing to pay a reasonable price for good water service when they are convinced that the price is reasonable; that the water utility is making only a moderate profit.

Please note that reference is made to good water service. All that has been stated in the foregoing and all that follows is based on "good water service." In this day and generation, there should be only one kind of water supplied to the public—good, wholesome, sanitary, unpolluted, safe water—the kind that the operator is willing to give his child or members of his family.

In the matter of a public water supply, the first, the fundamental, the essential and most important point is to have water of unquestioned purity. It should be like Caesar's wife, above suspicion. There is not much use in considering publicity of a water supply until its purity is of a high standard. Along with pure water, good pressure and courteous treatment should be closely associated. Courtesy and politeness are so inexpensive and bring such large returns that they should be constantly in evidence.

Making Waterworks Grounds Attractive.—After or during the publication of series of advertisements (call them "water talks" if you please), an effort should be made to get the public to visit the pumping station and other portions of the plant. Incidentally, the grounds around the station should be made attractive and pleasing. At Terre Haute, we had a landscape gardener make a plan for us, but usually the nurseryman can give excellent ideas on planting shrubbery and trees. First, we set out Boston ivy which now covers most of the outside walls. Shrubbery, such as Spirea and Barberry, were set close to the walls so as to cover the break between the foundation and ground. Trees and shrubs were planted on the outside lines of the grounds, leaving a grass plot for the center—a vista, I believe, it is called. Our grounds are so arranged that the view of the river from one point is the center of the picture with a green frame on either side. Such grounds are desirable for picnics and we invite the public to use them. So much of a waterworks plant is below the surface of the ground—out of sight—that it is desirable to have the visible portions as attractive as possible.

Luncheons at Waterworks Park.—During the past summer the Rotarians, the Kiwanis Club and the Exchange Club served noon-day luncheon on our grounds; the Lions and their wives served supper. We have tables (trestles and boards) sufficient for 140 people; our men set the tables, cover them with white paper (it comes in rolls), put on the glasses, forks and spoons. The caterer who is engaged and paid by the club, furnishes the eats, plates and paper napkins. We furnish the water, coffee, and sometimes small bottles of milk. In this way, the live wires of the city, the men who are doing things, visit our plant, see what we have and, judging by many comments, go away with a good impression of the local waterworks plant. We help serve by seeing that there is plenty of ice water for the thirsty. Of course, the newspaper men are present and the luncheons are duly written up with usually some reference to the waterworks. And it is always favorable publicity.

Some years ago, we invited, at different times, the Medical Society, the Young Business Men's Club and the Manufacturers' Club, etc., to visit our plant and we served the lunch. It gave us an opportunity of explaining the scientific methods of water purification in use at our plant.

Then we have an unusually fine tennis court which may be reserved by the public by telephone, no charge being made. The finals of tennis tournaments are played on the waterworks court. The court attracts people to our plant.

Once a year, we give a picnic to our employes and their families. The last two years the picnic has been preceded by a boat ride of a couple of hours on the Wabash. The lunch is served on the grounds at our station on the return of the boat. These are happy occasions and are looked forward to by most of our people. Photographs are made and each family is furnished with one and, in many cases, they are framed. It is customary for the newspapers to devote considerable space to the picnic and the photographs are reproduced in a subsequent issue. This is fine publicity as it shows the relations between the employes and the company.

Several years ago, we bought over 3,000 ⅝-in meters that come five in a box. The boxes were made of planed pine wood and were about the right size for flowers for a window or porch. It was announced in the newspapers that 600 flower boxes would be given away at the water office at 9 a. m. on a certain day to those holding coupons which were printed with the notice. The crowd that appeared almost blocked the street traffic and in 20 minutes the last box had been given away. Photographs were taken of the crowd and the cuts duly appeared in the press in addition to complimentary reading notices. This was fine publicity at a small cost.

Publicity from Multigraph Letters.—The record of fatal typhoid cases in Terre Haute since 1909 has dropped from 60 to 5 per 100,000 population. In the same period, the number of water consumers has increased from about 5,200 to about 9,000. A drawing 8½x11 was made showing these facts graphically, with a note calling attention to the relation between the number of city water consumers and the number of fatal typhoid cases. The two curves make a fine showing. For three years we have prepared these drawings and have made about 400 blue prints from the tracings. These, with a multigraph letter with typewritten addresses, have been mailed to a selected list of names. The list includes the state health officials, members of the Public Utility Commission, local officials, physicians, nurses, college and school principals, and all members of the Rotary Club. One of the letters was as follows:

"With the idea that you are interested in all the good things that Terre Haute enjoys, we are enclosing a blue print showing the local typhoid record for a period of 11 years, including 1920. It is interesting to note that as the number of our patrons has increased, the typhoid deaths have decreased.

Incidentally, we are striving to make the public water service of Terre Haute as near perfection as possible. We have an organization of trained men to watch over and guard your water supply; one of our faithful helpers has been employed at the pumping station for over 30 years. We have several men who have been with the company for a quarter of a century. Our chief engineer and chemist has been in the water business over 35 years.

An electric program clock calls the attendants every 30 minutes to examine the water. Some half dozen tests of the filtered water are made every day in our laboratory. Reports are made weekly to the State Board of Health, and inspection visits are made from time to time, without notice, by officers of that board. Your water supply meets the severe and strict requirements of the U. S. Public Health Service.

When you have visitors from out of the city, tell them about Terre Haute's good water.

Bring your picnic supper down to our park; make up a party and enjoy the view of the river and sunset. If you will telephone before starting, we will arrange to have tables for you sufficient to accommodate two and up to fifty. Our tennis court may be reserved by calling telephone 213 on the day before it is desired. It is advisable to call early, as the court is in demand.

Yours for Good Water Service.

P. S.: In summing up the good things of Terre Haute, keep in mind the unusually fine educational advantages.

Advertising Through Personal Letters.—The writer is of the opinion that the best form of advertising is through the public press, but there are occasions when a personal letter, multigraphed with typewritten address, is effective. A sample letter follows:

"There are times in every business of any magnitude that problems arise in connection with the water supply, such as arrangement and size of pipes, boiler incrustation, and the most economical method of using water.

"Our object in writing at this time is to suggest that we will be glad to assist our valued customers (and also our fellow citizens who may not be customers) insofar as our knowledge and experience can help in solving such problems as may arise in connection with water supply. We maintain a well equipped laboratory.

"Our Mr. Durbin, vice president and assistant manager, is civil engineer and chemist, a gradute of Ohio State University, and has had extended experience in the purification and distribution of water supply; he was also connected with the U. S. Housing Corporation in the work of laying out residence sections so as to combine beauty, utility and convenience.

"Our Mr. Taylor, Chief Engineer, Chemist and Bacteriologist, has been engaged in the water supply business for over a third of a century; his practical experience makes him a valuable man as advisor and counselor. Miss Kathryne Kintz, Chemist, is Mr. Taylor's assistant.

"Our Mr. Hanbarger has been with this company for 29 years; he is a thoroughly practical man in the matter of pumps, boilers and accessory equipment.

"Our Mr. Johnson has been in the water supply business for 20 years and is particularly conversant with the laying out and arrangement of supply pipes.

"We have a strong organization of practical men who have made the good water service of Terre Haute a reality—a splendid asset of the city. These men are available in helping you with any water supply problem that may arise. Unless there should be a very rare case requiring extended study, and an unusual amount of time, there will be no charge for the service rendered. We want our fellow citizens, neighbors and friends to have the benefit of the services of this organization."

We also sent a special letter to real estate men advising that the price of cast iron pipe was extremely high; that money was dear and hard to get and that a survey showed over 2,500 vacant lots on the lines of existing water mains. We enclosed extract from Mr. Brigham's article in March 1921 Atlantic Monthly to the effect that the U. S. Housing Corporation could have built houses where utilities were already installed much more quickly and cheaply; that the cost of improved vacant lots in the city was less than the improved acreage plus the great cost of utilities. Blue prints showing number of vacant lots on various streets, also blue prints of water mains, were furnished real estate men.

Telling the Public Why a Rate Increase Was Necessary.—After the great war was over, when cost of operation was still advancing and taxes had reached a high altitude, the Terre Haute Co. found it was absolutely necessary to have another increase in rates. A series of articles were used in all the newspapers. Copies of the petition for an increase in rates and a valuation of our property were delivered to city officials and all newspapers. Notice of the hearing were published and the matter was presented at a meeting of the directors of the Chamber of Commerce. At the meeting, a resolution was unanimously passed recommending that our petition for an increase of rates be granted. The hearing was held in Indianapolis; the secretary and two directors of the Chamber of Commerce were present and recommended the granting of our request. The Comission issued the order two days later, giving us what we asked for. Later, after an appraisal by the state engineers, the valuation was increased from about $1,300,000 to $1,800,000.

The Terre Haute city water supply is on the high efficiency plane required by the U. S. Public Health Service in connection with water used by interstate carriers. The U. S. usually fixes a pretty high standard; however, when it comes to water service, the public is entitled to the very best. No ordinary, slip-shod, hit-or-miss, come-or-go, run-or-stop water service is good enough for the public. To make a hit with the public, the utility must furnish excellent, high-grade, A-1, double extra, superfine service.

When the service is good, take time to let the public know what you are doing; do not fail to let it be known that the water service is excellent. Candles were not made to be lighted and then covered with a bushel measure, but to be set where the light will show. Publish all the good things you can about the water service you are furnishing. Let the public know something about the difficulties you must overcome in order to maintain high-grade service. The best way to tell it is not from the housetops, but through the advertising columns of the local press. Advertising space in the local press is valuable and should be used to inform the public about your business.

Operation of Mechanical Filters and Value of Simple Laboratory Tests

Abstract of a Paper Presented Nov. 15 At Annual Meeting of North Carolina Section American Water Works Association

By P. G. TURNER,
Filter Plant Operator, Wilson, N. C.

I find in my experience that I cannot efficiently operate my filters without making the required tests at least for tastes and odors, turbidity, alkalinity, free alum, free chlorine, and the jar tests for the proper dosage of chemicals. The color is not so important in the case of our Wilson water, but I consider the remaining tests necessary in order to keep well informed on the condition of the raw and filtered water. In making these tests care must be observed in order to insure accurate results. The apparatus must be clean and I use care in measuring samples to obtain the exact amounts required, as well as in reading the burette.

Determination of Alkalinity.—The determination of alkalinity is absolutely necessary to find out how much alkali is in the raw water so that the application of chemicals can be accurately adjusted and to check this application by knowing the excess of alkali in the finished water. This excess I try to keep around 8 to 12 parts per million. I prefer to use the "erythrosine" method for alkalinity. An accurate knowledge of the amount of turbidity in the raw and finished water is also of first importance, on the raw water because it indicates the treatment required, and on the filtered water as a simple index of the efficiency secured. Turbidity is measured by a rod test, the candle turbidmeter or bottle standards. As the third method seems more satisfactory for the rather low, finely divided turbidities such as found in our raw water, I prefer to use this. A gram of standard Fuller's earth is suspended in 1 liter of distilled water and forms the standard of 1,000. By diluting this standard turbidities of any degree can be made. These are kept in tightly sealed bottles and the samples to be tested, contained in similar bottles, are compared with the standards.

A third test I find most useful is the jar test for determining the amount of alum and lime required to most effectively and economically dose the water. This consists of a series of glass jars or little miniature coagulating basins as I call them. These hold a quart of raw water. In connection with these are some solutions of the alum and alkali used at the plant, made up to known strength. The solution of alum I use is such that one cubic centimeter put in a jar of water will correspond to ½ grain per gallon. The alkali solution is similarly made so that 1 cubic centimeter to a jar of water will correspond to 2 parts per million alkalinity. With this outfit any combination of chemicals can be tried on the raw water, by adding solutions to the jars of water and stirring vigorously with a glass rod.

Without these tests I would not be able to intelligently operate my filters, as they allow me to determine the proper amount of alum and soda ash necessary to get the proper size "floc" or coagulant, thereby allowing me to do 75 to 90 per cent of my purification in my coagulating basin. By so doing it relieves my filters of a lot of unnecessary work, and the saving of chemical and thousands of gallons of wash water. I attribute the excellent condition of our filter beds to this careful adjustment of coagulant, together with an excellent wash system.

Adjustment of Chemical Dosage.—In order to adjust my chemical dosage properly I find it necessary to have some means of measuring the raw water pumpage accurately. This is best done by a meter on the raw water discharge line, but we do not have this on the Wilson plant. However, each of our filter units is equipped with Builders Iron Foundry rate of flow gages, recording the rates through each unit. An intergrating attachment gives the total water passed for any period of time. Whatever the device used, its accuracy should be tested at intervals. In the case of Wilson I find that this can be done by dosing the influent valve to the filter and measuring the drop in water level for one minute. The area of the filter in square feet multiplied by 0.625 times the drop in inches gives the gallons per minute through the filter. Knowing in this way the exact amount of water to be treated the second important thing is exact measurement of chemicals to apply to the water. All chemicals should be carefully weighed on suitable scales, and added to known quantities of water in the solution tanks. In making up solutions it is highly important that these should be thoroughly stirred or else the solution will be stronger at bottom of the tank than at the top. This is done at Wilson with power driven agitators. After the solutions are made the important thing is absolutely even application of it to the water. This is the operator's most important task and he should keep his feed under constant supervision and at frequent intervals see that there is no clogging of the feed devices and that the flow is constant and uniform.

Cleaning Coagulation Basin.—The coagulation basin needs little attention from the operator, except to clean it out as soon as too much settled material collects in it. We find it necessary to clear the Wilson basin every month. The proper time for cleaning is apparent when settled coagulant begins to stir up and comes over on the filters. Cleaning too frequently makes a useless waste of water and considerable labor expense. At Wilson we have an electric alarm system on our basin and chemical solution tanks and I find it very satisfactory. This often saves considerable waste of chemicals and coagulated water besides preventing damage from the overflowing water to the plant equipment. The arrangement is simply a float in the basins and tanks which will close a circuit and ring a bell in the filter house when the level reaches a predetermined height.

Chief Points in Caring for Filter.—In caring for the filters the chief points to be investigated are:

1. The condition of sand and gravel.
2. The rate of washing.
3. The rate of filtration.
4. The operation of the effluent controller.

I make weekly examinations of each unit to see that the beds are in proper shape. Daily I examine the sand by running a pole through beds while washing to be sure that there are no lumps or mud cakes. I also catch a sample of water going over the wash water troughs to see if any sand is being washed out. I examine my rate controllers each week, preferably just before washing and calibrate them occasionally to see that they are correctly set. To do this I close the influent valve and note the fall in water level over the whole area of the filter bed and calculate as previously described the rate of filtration in gallons per minute. I then compare this with the setting of the controllers and correct accordingly. I repeat this for various rates and for each filter unit. I check the regulation of the controllers by noting the rate as above, with different heads over the filter sand or vary the head by throttling the effluent valve. Our units all have Builders Iron Foundry controllers.

Washing the Filters.—In washing my filters I am guided entirely by my loss-of-head gages, with which each unit is equipped and I consider this the only accurate and intelligent way to wash. These measure the friction loss through the matter, sand, gravel and underdrainage system and when operating properly are an index to the load distributor among the filters. When the loss-of-head increases to 7 or 8 ft. greater than the initial loss-of-head or loss-of-head obtained when the filter is first put into commission after washing, that I find is the proper time to wash. It is at this point I have found on my filters, that the controllers are wide open. As the loss-of-head will increase fairly uniformly for all units in service running at same rate, if any unit shows an excessive loss-of-head as compared with the rest, under normal operating conditions, I know there is something wrong with the gravel or strainer system. It is either clogged or otherwise obstructed. Such unit is immediately thrown out and investigated. We have a sampling cock on the effluent from each unit and at frequent intervals samples are taken for turbidity test and any filter showing an inferior effluent is always shut down until the trouble can be located and repaired.

The wash water at Wilson is furnished from a special wash tank that is calculated to give exactly 24 in. vertical rise on the filters. This has been shown to be satisfactory and I have tested it by washing the filter throughly clean and with different openings of wash valve I collected samples of water from the wash troughs in glass jars to see if any sand appears. The highest showing no sand is the rate used. We have a pressure gage on our wash line as it enters the filters which furnishes a constant and convenient check on wash water. Occasionally, however, I check the wash rate by running the water level in filters below troughs, and opening wash valve with all other valves closed. The vertical rise can thus be easily determined with watch and rule.

I wash until all the heavy dirt is removed, but not until the filter is perfectly clean as I prefer to have a film of coagulant jelly about ¼ in. thick over the entire sand surface to form a matte when starting the filters, and to wash beyond a certain stage requires an excessive amount of wash water. Our total time for washing is about 4 to 7 minutes, depending upon the condition of the raw water, length of run, etc., and we normally get 24-28 hours' run between washings.

The beds are carefully observed during washing and isolated mud patches suggest stopped-up strainers, especially if the sand beneath is not clean. Craters of sand are signs of water channels due to stratification, broken strainers.

I find that it is very important that the wash water valve should be opened and especially closed very slowly, as this has the effect of leaving the sand stratified, horizontally in layers of increasing fineness upward and in the best condition for filtering.

I find it not best to wash all filters in succession, but rather to so manipulate the washing that the time for washing the several units is divided proportionately among the shifts. This tends towards greater uniformity of the effluent and causes less unbalancing of operating conditions.

In a small plant like ours, say of 4 units, washing one filter unit throws 30 to 50 per cent more water into each of the other, which may disturb their operation, especially with a small coagulating basin or poorly regulated controllers. Our filters have been running for three years and I find that the wash water rise is exactly the same for same valve opening as when the plant was first built, showing that the underdrainage system and beds are in perfect condition and I have never had mud balls. I attribute this good condition entirely to extreme care in washing and in looking out for the beds.

When a filter is operating silt and coagulum are continuously collecting in the upper part of the sand, causing an increasing resistance to the passage of water, until a point is reached at which the pressure of water is above the sand is not sufficient to force the rated quantity through the filter. A vacuum is then formed below the sand surface, as the water is running through the lower part of the sand faster than it can pass through the clogged upper portion under the water head alone and this vacuum aids in keeping the filter up to its capacity. This decrease, however, in pressure causes dissolved gases to come out of solution and collect at point of maximum vacuum, forming a film of gas across the filter which effectively stops the passage of water and makes the filter air bound. This gas is partly air and partly carbonic acid gas. If the effluent valve is closed the gas will rise to the surface in large bubbles, breaking up the matte and forming passages through the sand. In a case of this kind I wash my filter before placing it into service again, as the matte has been broken and I could not possibly get a good effluent. There is a tendency in such cases, also, for a scum and film to collect on the walls of the filters near the water line and on wash troughs. This to me is unsightly and I carefully clean it off.

Chlorination.—I find that chlorine is a much better germicide than hypochlorite of lime as the latter will lose its strength when coming in contact with the air. We also find that water treated with hypochlorite very often has an unpleasant taste, suggestive of iodoform. I do not know the cause of this, but probably the action of hypochlorite on organic matter is partially accountable for it, since the pumpage varies and rate of hypochlorite solution is uniform, but not so the liquid chlorine, the convenience and simplicity of operation as compared to hypochlorite being obvious. There is also no annoyance from dust or fumes with the liquid chlorine.

Taste and Odor in Chlorinated Water

Abstract of a Paper Presented Nov. 1 At Annual Meeting of the Iowa Section of American Water Works Association

By EDWARD BARTOW and R. M. WARREN,

Head Department of Chemistry, and Graduate Assistant, University of Iowa.

The present work was carried out in search of some relation between taste on odors and chlorine and to see what effect certain treatment such as aeration and standing would have on the taste and odor developed from chlorine.

Waters from different sources are different in many ways and so the results of chlorination naturally varies greatly. Waters of different character were used in the experiments.

Determination of Amount Chlorine Required.—The first experiment was made in an attempt to determine the amount of chlorine required to give a taste in a water of highest purity, i. e., distilled water.

This amount was determined by Bartow and Van Brunt to be 3 p.p.m. in distilled water, but the following data from the writer's own experiment are presented to further justify this amount in the present work:

Sample.	p.p.m.Cl_2	Taste.	Odor.
1	1.7	0	1
2	3.4	3	3
3	6.8	4	4
4	13.6	5	5

This experiment was carried out in breakers containing varying amounts of applied chlorine with the result that 3 p.p.m. had to be applied to give a taste which would be disagreeable.

An amount less than this was chosen for subsequent experiments so that taste and odor given would be due to action on impurities present rather than chlorine.

An experiment carried out with river water containing varying amounts of organic matter such as algae shows a direct ratio between the amount of impurities present and the taste and odor developed.

To make relation plain the table below is given to correlate the p. p. m. of chlorine absorbed and taste and odor given.

All observations were made on the same samples.

Jar.	Oxygen consumed.	Cl₂ absorbed.	10 min.		30 min.			60 min.		
			T	O	Cl₂ absorbed.	T	O	Cl₂ absorbed.	T	O
1	20.8	1.8	5	5	1.9	5	5	2.0	5	5
2	9.9	1.7	5	5	1.8	5	5	1.9	5	5
3	9.5	1.6	5	5	1.8	5	5	1.8	4	4
4	5.5	1.1	3	4	1.7	3	4	2.0	2	3
5	3.8	.9	4	5	1.3	2	1	1.7	2	3
6	.1	.6	4	4	.9	3	3	.9	3	4

The same experiment also shows that measured by oxygen consumed chlorine absorbed also varies with organic matter present. This would indicate that taste and odor varies with chlorine consumed rather than residual chlorine.

Effect of Aeration and Time of Standing upon Taste and Odor.—The aeration experiment is made to further associate the phenomenon of taste and odor with amount of chlorine present and the amount of oxidized materials present. The amount of chlorine absorbed was the measure of oxidized material in the previous experiment. No means were used to measure the oxidized material, it being assumed that the more organic matter present in the beginning furnished the greater amount.

When excess chlorine was added compressed air was used. All six bottles were connected to one bottle containing a stopper with seven holes,—one hole for air inlet and the other six for outlets to the six bottles.

The following table shows the relationship. The same jars and material of the previous experiment were used, after the end of the 60 minute absorption period.

Jar.	Aerated one-half hour.			Standing closed five hours.		
	Cl₂ Residual.	T	O	Residual Cl₂	T	O
1	0	4	2	0	5	5
2	1	4	1	0	4	4
3	1	3	1	0	3	3
4	(0)	2	1	0	1	2
5	.3	2	1	0	2	1
6	.3	1	2	0	2	2

Conclusions.—The conclusion may be summarized:

1. Aeration removes some taste and much odor.
2. Presence of chlorine increases odor but not essential to it.
3. Taste varies as the amount of oxidized material present, while odor becomes constant after treatment.
4. On standing even more oxidation takes place and with no escape the bad taste and odors developed, accumulate
5. Standing in open or aeration should be good treatment for water after chlorination.

Studies Made on Gas House Waste.—Among the numerous industrial wastes giving trouble in water purification, gas house waste take first place.

The first thing one would want to know is how much gas waste could be in water with no taste and odor before chlorination. The following experiment was made to answer this question concerning the water gas waste from the local plant. This would be about typical of any gas waste going into streams and rivers. The waste that was used in this experiment is called "Drip water". It is the water which condenses in the storage tank and collects into a tank just outside. The oily material settles to the top and suspended matter to the bottom. The clear brown liquid in the middle was siphoned and used.

500 c.c. distilled water containing varying amounts of waste were observed as follows:

p.p.m.	Pct.	Taste.	Odor.
80	.008	slight	marked
40	.004	none	slight
20	.002	none	none

Water would have to contain around 80 p.p.m. or .008% to be disagreeable if clarified and used unchlorinated.

500 c.c. of distilled water treated with varying amounts of gas waste and 1 p.p.m. of chlorine was used for observations to determine how much of the water gas waste used, would give taste and odor. One part per million of chlorine with one part per million of waste gives taste.

As in the case of river water the odor is found to decrease faster than taste, both by standing and by decreasing the amount of waste.

Conclusions. — Chlorinated water may taste other than that given by excess chlorine.

This taste and odor may be developed by other oxidizing agents than chlorine,and generally increases with chlorine absorbed.

Aeration may increase taste by further oxidation rather than remove it.

Oxygen consumed method of control good only where taste and odor are due only to excess chlorine.

Water should have access to air to give escape to odors developed.

For any given water there is an oxygen consumed value above which chlorine will give taste and odor. When this limit is reached some method of oxidation should be used before sedimentation and filtration, so as to give opportunity for dissipation of taste and odor during treatment and before final chlorination.

Colorimetric method not accurate if water contains any appreciable amount of phenol or cresol.

Actuarial Factors in Design of Irrigation Structures

Economics of Storage Works, Storage Capacity, Flood Prevention, Spillway Provisions, Cross Drainage Works, Etc., Outlined in Paper Presented Before Lethbridge Branch of the Engineering Institute of Canada

By H. B. MUCKLESTON.

In presenting this paper the author wishes to say in advance, with the object of forestalling possible criticism, that it contains little or nothing original, or that has not been said before by others better qualified to say it. Rather is it a compilation of a few well known principles which are often overlooked, or not sufficiently emphasized. Engineering literature contains countless descriptions of works built, and these descriptions often deal exhaustively with the stresses and strains and peculiarities of design. But the economic factors are seldom mentioned and hardly ever even fairly well covered.

Before we can conscientiously consider any design the best possible design, we must satisfy ourselves that economic principles have been followed and their requirements fulfilled.

Interest on a dollar can be earned, (or saved) in two ways. The first and most obvious way is not to spend the dollar. The second less obvious way is to spend two more dollars of capital in order to save the interest on four dollars which would otherwise be spent in maintenance and operation charges.

If engineers were omniscient they could always follow exact economic principles and know they were right; but lacking that faculty they must do the next best thing. Certain basic facts are always lacking in the data of engineering studies, and in default of the facts reliance has to be placed on the probabilities based on the best information obtainable.

The more complete our records, the better we are likely to prove as prophets. With the probabilities calculated it is an actuarial matter to determine the justifiable present expenditure to avoid a given probable expenditure at any set time in the future.

Economic Problems In Storage Works Design.—The economic problem in the design of storage works is usually studied under the following heads:

A. Determining the economic value of storage.

B. Determining the available storage from the run-off records over a series of years.

C. Determining the capacity curve for a wide range of dam heights.

D. Determining the unit-cost curve for a wide range of capacities.

E. Determining the economic storage capacity to be developed.

The economic value of storage is a complex function of a number of somewhat erratic variables. In general the steps in the problem are, first to find what water is worth delivered at the farm. Second the cost of delivery. Third the residual, which is roughly the value of the storage. This looks simple enough; but the apparent simplicity vanishes when the different steps are tackled. It will, however, be assumed that this part of the problem has been solved, and also that the available storage has been calculated from the records, and that a table of capacities for various depths has been prepared. This brings us up to the calculation of the unit cost curve, and here the engineer's economic problem begins in earnest. The cost at any capacity is a sum of the capital cost of the works and the capitalized cost of the maintenance and operation, plus, in some cases, a further item for the renewal of the works at some future time, amortized insurance charges and some other special charges which are applicable in certain cases but not in all.

It will be assumed for purposes of illustration that the cost of storage is represented entirely by the cost of the dam and its appurtenances. If there be other works to be considered the same principle will apply. It will be necessary first to decide on the material and type of construction to be employed in the dam.

If there is any very wide variety of choice possible with the local conditions as they exist, there is a secondary economic problem involved in the choice; but if local conditions dictate the material and style of construction as they often do, the problem is simpler.

Dams have been built of earth, loose rock, masonry, either as gravity or arch dams, wood, steel and reinforced concrete; and each material introduces some secondary economic problems peculiar to itself.

If the dam is to be of earth or loose rock, a separate spillway is a necessity and a certain freeboard must be provided. The economic problem is, how much? Freeboard and spillway capacity are safety measures and both cost money. How much money is it justifiable to spend in anticipation of something happening at an indeterminate date in the future?

Spillway Provision for Floods.—Spillway capacity is provided to guard against floods and freeboard is provided as bulwark against wave action and to enable the spillway capacity to be utilized. If too much of either is provided it may never be used and our dollar is not earning the most interest, if too little is provided the whole works may be destroyed and our dollar may cease to earn any interest at all.

Evidently the possible flood to be provided against is the important question in this stage of the problem. It must be considered that, given time enough, any size of flood may occur on any kind of stream. The various possible causes of high water in these latitudes are (a) a heavy winter snowfall in the mountains, (b) a late quick spring, (c) heavy rain on the watershed, (d) precipitation on previously saturated catchment areas, (e) precipitation in which the storm center moves down stream, (f) breaking of logs and ice jams, beaver dams, etc., (g) destruction of other storage works higher up in the valley. Any combinations of these causes may occur. Any one of these acting alone may cause high water, and possibly could, though not necessarily would, cause what might be called unusually high water, or perhaps moderate floods. Three would probably cause moderate floods, and might cause unusual floods, while all together might cause floods which could be called disastrous. The records, such as they may be, give an indication of how frequently each one of the causes

No.		
1	Once in 2 years frequency equals	½
2	Once in 6 years frequency equals	1/6
3	Once in 10 years frequency equals	1/10
4	Once in 12 years frequency equals	1/12
5	Twice in every year frequency equals	2

(except the two latter) is operative on the average, and by combining these frequencies we can arrive at the probability of any conjunction of two or more. For example let there be five possible events and let their frequencies, as established by a long series of observations be as follows: Then the probabilities of No. 1 and No. 2 coming in the same year is 1/12; of Nos. 1, 2 and 3—1/120, and of all five happening in the same year, 1/720. Further, suppose examination of the records shows that No. 1 happened in May on nine out of ten occasions. The probability of its occurring in May of any selected year is evidently ½ × 9/10 = 9/20. Similarly, the probability of No. 2 occurring in May of any year might be 7/60 and that of Nos. 1 and 2 occuring together in May of any year would be 63/1200.

This is the ideal method of attack in such problems, but it is seldom that it can be used, as our information in the shape of records seldom takes just this form. What the records do show is the relative frequency of floods and high water of varying degrees of magnitude. Each high water or flood may be considered as the result of one or more causes, acting with greater or less intensity; and the frequency of the various maxima of discharge may therefore be considered as a measure of the frequency of coincidence of the various acting causes or degrees of intensity. If therefore the record of previous years is extensive enough it should be possible to calculate the probability of a flood of any given magnitude occurring in any set period. This calculation may be made by following the mathematical theory of probability which is a somewhat laborious business or it may be accomplished with sufficient accuracy by blotting the recorded observations on probability paper, as described by Allen Hazen, M.E.I.C. As an example: The Ohio River at Cincinnati has been under observation for 60 years and the records of the gauge heights so plotted show that for 99 per cent of those years they have exceeded 33 ft., for 90 per cent they have been in excess of 41, for 40 per cent they have exceeded 53, for 5 per cent they are more than 64, and for 1 per cent more than 69. An extension of the curve shows that a flood in excess of gauge 75 might reasonably be expected only once in 1,000 years. This does not mean that such a flood will not occur next year or the year after. It is merely an indication of the reasonable betting odds on the chances which, in the long run we can afford to take.

Failing any other means of fixing the maximum flood to be provided against, recourse must be had to some of the many formulae for this purpose; but it must be emphasized that these formulae have a very limited range of usefulness and can only be applied with a very large mixture of judgment. There is one formula which is said to give good results and as it is frequently used it may be given here without apology:—"Convene an extraordinary session of the Ancient and Honorable Order of Highwater-liars and take a vote, then provide for twice as much."

Economics of Flood Prevention.—After the probabilities of any given flood discharge are determined, it is necessary to determine how much it is justifiable to spend in capital in order to avoid paying damages which such a flood might cause in the future. For instance, let it be assumed that the calculations show that a flood of 60,000 sec. ft. might be reasonably expected on the average once in 100 years or that its probability is 1/100, 50,000 once in 20 years, probability 1/20, 30,000 probability 1/3 and so on. If this is the true law of probability, then a flood of 70,000 might be anticipated as occurring only once in 500 years and one of 80,000 only once in 5,000 years. If money is worth 6 per cent how much is it justifiable to spend on provision against floods, which otherwise might wipe out the investment? If the event may occur once in ten years, with money costing 6 per cent, we are justified in spending about 56 cts. for every dollar of investment. If it may occur once in 30 years the justifiable expenditure is about 17 cts., and if the period is 100 years it is only 3/10 ct. This is not quite the whole story because the failure of the dam might have consequences far beyond the mere loss of the first investment, and what must be considered is not the investment wiped out but the total of the possible damages.

Having decided on the magnitude of the probable flood to be provided for, it is next necessary to determine its duration, and the necessary flood freeboard, as measured from the storage capacity above normal H.W.M. Assume for example that the stream we are dealing with may be reasonably expected to discharge 20,000 sec. ft. and that such a flood might be reasonably expected to exceed 10,000 for a period of 48 hours. From the hydrograph of such a flood we find that the discharge during that period might amount to 60,000 acre ft. How high will the reservoir rise, assuming it was full to H.W.M. when the flood started?

By calculation it is found that the storage capacities above H.W.M. are:

	Acre feet.
1st foot	8,000
1st-2nd foot	18,000
1st-3rd foot	30,000
1st-4th foot	44,000

It will be further assumed that the spillway is a simple overfall weir and that its discharge for any given head is a direct function of its length. The next step is to construct by a—trial and error—process a hydrograph for discharge of the spillway on the basis of an assumption as to length. This hydrograph together with that of the stream and the curve of storage capacities will show how much of the flood water passes directly through the reservoir and how much goes into temporary storage, or in other words, how high the level of the reservoir will rise. It is evident that this height is some function of the length of the spillway crest and by making several such calculations a curve of flood heights can be plotted against spillway lengths, or spillway costs.

Freeboard and Wave Height.—At this point it is necessary to consider the question of freeboard as affected by wave heights. It will be assumed that the general design of the dam has been settled and that we have selected an earth fill dam as the best type for the situation. The upstream slope will be assumed as 3-1. The possible wave height is a somewhat complex function of the fetch, or the longest stretch of open water over which the wind may act in a straight line. It does not appear to be affected much by the velocity of the wind, which only alters the length and velocity of the valve.

With a fetch of 6 miles and in deep water we might expect a wave height of between 4 and 5 ft., and if a wind velocity of 110 miles per hour is a reasonable expectation, such a wave might have a length of 70-90 ft. and a velocity of 19-22 ft. per second, and the pressure developed by impact of such a wave might be as high as 2,500 lb. per square foot. These figures are for open water; as the water shoals the waves become shorter and higher and the velocity somewhat less. For such a case as the dam under consideration a wave height of 6 ft. is not impossible and our freeboard should be something greater than this or else a parapet of proper design should be provided. This free board must be added to the flood heights as determined above.

We are now in a position to calculate and plot a curve of costs based on various top elevations. Since these elevations have been shown to depend on the length of the spillway crest, this curve will show us which spillway length is the most economical in capital cost for a given capacity.

The cost of maintenance will not be a constant but will vary somewhat with the height, length of spillway, area of surface protected by rip-rap or other means, and with other factors of more or less special application.

The above analysis is based on the cost of the dam and spillway only. There may be other considerations such as relocation of railways and highways, land damages, and the effect on other developments above or below, etc. Again, the cost of maintenance, which is a relatively small matter for an earth dam or a masonry structure, may be relatively great in the case of a framed structure of steel, timber or reinforced concrete.

Storage Capacity.—In some cases the real economic problem is the amount of storage capacity to be provided. So long as the run-off of the stream is in excess of any possible economic storage, the quantity to be developed is more or less closely determined by the value of the stored water. But in the reverse case where the whole run-off, even in the biggest years, could be stored at less than that value, it may not be economical to develop storage for the maximum possible quantity because that quantity occurs so seldom. For instance, on a certain stream it is found from the records that the mean or average annual run-off over a long series of years is 100,000 acre feet. The maximum annual run-off during that time has been 200,000 acre feet which occurred in only one year out of the 50 for which records are available. It would hardly pay to develop storage to that capacity even if it were feasible. On the other hand a capacity of only 100,000 acre feet might be economically too small.

If the mean annual run-off be calculated for a long series of observations and the excesses or deficiencies be tabulated in order of magnitude it will generally be found that these differences, regardless of sign, vary in frequencies inversely as their magnitude. If the observations extended over a long enough period it would probably be found that these differences followed the mathematical law of error. Usually the series is not long enough on any one stream to demonstrate this, but by combining the records of several streams it may be shown that the law holds approximately, and the probability of a run-off of any magnitude may be calculated. The question then resolves itself into calculating how much it is justifiable to expend in providing storage capacity which may be filled only in a relatively small proportion of the years. Incidental to this question is the use of the stored water. Irrigation is provided for two reasons, and one or both may be operative. The first reason is that no crops can be grown in any year, or in a certain proportion of years without it, i.e., irrigation is an absolute necessity for part of the time. The second reason is that more valuable crops can be grown any year with than without it. The first is preventive irrigation, the second is productive. Manifestly, when a thing is a necessity we can go to greater lengths to secure it than when it is a luxury, or at least, we should feel justified in spending more money or taking a longer chance. It will not ordinarily pay to develop storage which can only be filled in one year out of twenty, it will seldom pay to anticipate the one year in forty, and it may be safely said that under no circumstances should we be justified in looking ahead much more than one year in sixty. Similarly in calculating the storage which may be reasonably counted on we might ordinarily neglect the low water years which occur only once in twenty, generally the one in forty, and almost certainly the one in sixty.

So far the discussion has proceeded on the tacit understanding that the life of the reservoir is practically infinite. In theory every reservoir constructed on a silt bearing stream is due for extinction sooner or later, by filling up with silt, unless special measures are taken to combat it. This may be so far in the future that economically its life may be considered infinite. But this is by no means always the case. There is one example in New Mexico, in which 61 per cent of the whole capacity has been filled up in 12½ years. Another, in Spain, built in 1875, is now silted full and has been for many years. Evidently such storage must be exceedingly cheap or it cannot be an economical development. In some cases it is possible to prevent this silting up by spending enough money on prevention measures. At Assouan the problem was solved by building what is to all intents and purposes a moveable dam and allowing the heavily silted flood waters to pass practically unchecked, while storing only the lighter laden or relatively clear waters of the falling flood. In other cases dredging may be an economical solution. But whatever solution can be adopted it can only be had at a price and the storage may or may not be worth it.

Cross Drainage Works.—Every irrigation canal, in the upper reaches at any rate, crosses the country drainage. This drainage must be taken care of either by taking it into the canal or by passing it across. It is not always either possible or wise to take it into the canal, and in any event, the discharge which may be expected in any drainage channel is a matter of some consequence. The unknown element is the discharge to be provided for. If we guess too low the smashup comes early in the game. It can never be known if the capacity is just right, and a margin of safety is a comfortable thing to have in reserve. But if we guess to high there it is an unnecessary expenditure. There have been some startling illustrations of extraordinary discharges from insignificant streams, and yet the number of such cases compared with the number of drainage crossings is almost zero. Probably the most instructive example of such a discharge is the Kali Nadi flood of 1885 in the Lower Ganges Canal in India. The river in normal times is a small stream of insignificant proportions. It has a catchment area of 2,377 sq. miles, but, ordinarily its bed and banks are cultivated. In 1884 a flood of 50,000 sec. ft. occurred and did some damage to the canal crossing, which had been designed for only one quarter that amount. While the old crossing was being repaired designs were made for a new structure to pass 60,000 which it was expected would be sufficient. In 1885, before the new structure was commenced, a flood of 133,000 sec. ft. occurred and completely obliterated the aqueduct and every bridge but one on the stream for 150 miles. Even the natives, who are taught by tradition to keep their villages well above danger, were no better off, as many villages were swept away.

This particular case has value in showing that local indications of flood discharges are not always reliable. Just below the crossing there was a road bridge, much more than 100 years old. Flood marks above and below this bridge were quite plain and from these and the dimensions of the bridge it was calculated that a flood of 8,500 sec. ft. was possible. The crossing was made a little larger than this, having a capacity of about 12,000. After the big flood subsided it was found that this old highway bridge was the only structure intact in 150 miles of the river. It had merely been submerged and was hardly damaged at all.

In very few cases have these drainage channels been under observation for any great length of time, if at all. Their catchment area can usually be determined with fair accuracy and its character can be ascertained by inspection or survey. None of the formulae for flood discharge are much use, as they all contain a coefficient and most of them ignore the rainfall. The precipitation record of the catchment area, or, if not available, on a neighboring one of the same character, is the best guide. If this record is long enough and detailed enough it is possible to calculate curves of probability for a wide range in duration and intensities. The direction of travel of cyclonic storms is almost a constant for any locality, and from the curve of probable intensities, a similar curve of probable run-off at the site can be derived. The question is complicated by climatic conditions, specially in this country where snowfall is a principal factor in the discharge of such channels. In any event we should try to establish by past history, a frequency curve for flood discharges of any selected magnitudes. Having done this it is possible to calculate the justifiable expenditure now, to avoid complete disaster at any future time. For simplicity let it be assumed that the cost of a certain cross drainage work is direct straight line function of its capacity and for further simplicity assume that each cubic foot per second will cost $100. It will also be assumed that our analysis of the probabilities has shown that a flood of 100 sec. ft. may be exceeded in nine years out of ten, and that for other floods the frequencies are:

200 sec. ft. frequency	.60
250 sec. ft. frequency	.42
300 sec. ft. frequency	.24
350 sec. ft. frequency	.11
400 sec. ft. frequency	.03
450 sec. ft. frequency	.014
500 sec. ft. frequency	.003

If money costs 6 per cent what is the justifiable expenditure? The costs will be for:

100 sec. ft.	$10.000
200 sec. ft.	20,000
250 sec. ft.	25,000

300 sec. ft.	30,000
350 sec. ft.	35,000
400 sec. ft.	40,000
500 sec. ft.	50,000

As long as the structure lasts we must pay interest and when it is destroyed we should have a sum of money ready to replace it. At 400 sec. ft. its expectation of life is 33 years, cost $40,000, the annual interest would be $2,400 and the annual charge to sinking fund would be $240, total $2,640. On a 350 sec. ft. basis the expectancy is nine years, cost $35,000, interest $2,100, sinking fund $3,045, total $5,145. For 450 ft. the total annual charge is practically $2,700 and for 500 sec. ft. about $3,000, so that in such a case it would pay to build for a flood of about 400 sec. ft. although such a flood might be expected to occur not oftener, on the average, than once in every 33 years.

The Value of Permanence.—Absolute permanence is not a possibility, even the eternal hills decay. What is usually meant by permanence is a useful life so long that the annual charge to replacement account is practically zero. Even this kind of permanence is not always economical, for it may cost more than it is worth. There is for each individual case a useful life which in the long run is the most economical. The annual charge for maintenance and operation may be divided into two parts. One part is the cost due to progressive deterioration in the structural integrity of the work, the other is a more or less constant charge due to conditions of service or ordinary wear and tear. The first part is practically zero with a new structure but rapidly increases in an increasing ratio as the structure gets older. Sooner or later this charge is equal to the interest on the cost of a new structure and at that time other things being equal it would be economical to rebuild. There is also a depreciation charge which is the cost of the new structure spread over the useful life of the old.

For example let us assume that a certain work has been designed and it is estimated that for a structure of type "A" the cost would be $1,000 and the useful life 15 years. For type "B" the figures are $1,200 and 30 years, and for type "C" $1,500 and 50 years. The cost of operation would not vary materially for the three types. It will be further assumed that the original money is raised by the sale of stock bearing 6 per cent and that new money will cost the same rate.

The annual charges for these types would be about as follows:

	Type "A"	Type "B"	Type "C"
Cost	$1,000.00	$1,200.00	$1.500.00
Life	15 years	30 years	50 years
Interest	$60.00	$72.00	$90.00
Depreciation	41.70	13.00	4.50
Amortization	43.00	15.60	4 50
Av. maintenance	30.00	36.00	45.00
Av. annual cost.	$174.70	$136.60	$143.00

It has been assumed that amortization and depreciation investments will bring the same rate of interest as the original money, which is not by any means always the case. As they stand, however, the figures show that even a relatively high degree of permanence may cost more than it is worth and that a moderate degree may be better than either too much or too little.

The Cost of Operation.—It is frequently possible by refinements in design to save a considerable annual amount in the costs of operation. As an extreme case we might take a system where all the distribution is by means of closed channels. In such a case, provided the pipes could stand the pressure there would be very little cost properly chargeable to the delivery of water, as each user would open and close his own outlet at his own convenience. Such a happy state is of course seldom a practicable one; but we can conceive of various intermediate conditions which might be practicable, if they could be got economically. The question thus arises of how much is justifiable to spend in capital to save operating costs.

If we assume that the capital is raised on 30 year bonds at 6 per cent selling at par, the annual cost to the owners of the system for the money alone will be the interest plus the sinking fund which will work out at 7.3 per cent. It is not probable that the bonds would sell at par but at a discount, and we will assume for ease in calculating that the actual cost of the money is 8 per cent. If a certain annual expenditure in operation and maintenance can be saved by spending a little more capital, or, which comes to the same thing, an equal annual revenue can be obtained, are we justified in spending it? Our additional capital expenditure must earn (or save) sufficient money annually to do two things, pay the interest and the sinking fund. On the assumed conditions we might spend $11.26 for every dollar we expected to earn or save, and at the end of the period be clear of debt. If the period were in perpetuity we could spend $12.50 while if it were ten years the amount would be $6.71, similarly at 3 per cent the amounts are $19.60, $33.33 and $8.53.

This paper is intended to show that good design involves considerations additional to those of stresses and hydraulic coefficients that the best design is not of necessity the cheapest in first cost or operation, and that the designs are as much dependent on the financial foundation as the structural.

New Data on Land Drainage Machinery

In recent years there has been considerable improvement in machinery for excavating drainage ditches and an increase in land drainage work. To place the latest information on the subject before persons concerned with drainage work, the United States Department of Agriculture has issued a revised edition of Department Bulletin 300, Excavating Machinery Used in Land Drainage, by D. L. Yarnell, Senior Drainage Engineer. In the preparation of this bulletin, which has been entirely rewritten, studies have been made in many parts of the country, where size of ditch, size of project, wet or dry conditions of soil, stumps encountered and other factors make various machines and methods of operation desirable. The bulletin is designed to be useful in determining what type of machine will be best suited for a given project, the cost of the machine and of getting it ready for operation, size of crew and supplies necessary for operation, and rate of progress to be expected. The scope of the bulletin is limited to power machinery such as would be used on projects of some size.

Stockton, Calif., to Have City Manager.—At an election Nov. 28, voted 3 to 1 in favor of the city manager form of government.

Incentive for Efficiency in Management of Public Utilities

Abstract of a Paper Presented Nov. 2 at Annual Convention of Central States Section of the American Water Works Association

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In searching for a solution to our question, it is probably vital that we bear in mind the reason for the type of management obtaining at different kinds of plants. Needless to say that the reason for the existence of a private company is in order that a net revenue be obtained for the stockholders or the owners, and an appeal can be made to the management of a private plant successfully through the item of "net revenue."

The reason for municipal ownership and operation is to provide a service for the inhabitants, and activities of the city in question, and there should exist sufficient desire that this service be provided at a fair cost. It is reasonable to assume, however, that for the average case the net revenue idea would not be so effective, to this end, as with the average private plant. We must look further for our source of incentive, and the key may be found through the pride of the public servant, who is responsible for the particular utility, or through his desire to make his position more secure. This latter avenue may prove equally effective in case of the private plant.

Rules of Public Service Commissions Must Create Incentive.—Coming now to the question of economy and dealing first with the private plant, it is possibly near the truth to say that the rules and practices of various public service commissioners must create and maintain an incentive for economical plant operation, or otherwise, we are heading towards increasing inefficiency, carelessness and extravagance for those plants affected.

A water company files an increase in rate schedule, and in order to have a little more assurance that the new schedule will be well supported by the facts, the manager often, and logically, permits the expenditure of a little more money here and there than he would sanction under other conditions. At the same time, these added costs may be of such a nature and in such amounts as to be entirely obscure from any criticism of the commission.

The commission can penalize the exceptional case of extravagant operating cost, but they can hardly penalize the case of average efficiency. This average efficiency may go from bad to worse, if there is no compelling reason for its not doing so, and so long as there is a reason for its doing so, though deplorable that reason be. Commission orders, or coaxing, or driving will not be an ultimate success to this end. There must be an incentive in order to produce desirable results.

Comparison of Commission Practice.—A brief study has been made of the more outstanding items in commission control, for the states incorporated in the central states section (as an example), in an effort to discover any practices which give positive encouragement for economy, and

TABLE I—COMPARSISON OF COMMISSION PRACTICE.

Item of practice.	Indiana.	Ohio.	Pennsylvania.	West Virginia.
1—Control over municipal plants	Ordinance by appeal.	Information.	Generally none.	Complete.*
2—Control over private plants	Complete.*	Except prior cont'cts.*	Complete.*	Complete.*
3—Plant valuation—				
Price formula	Average 1911-1920.	5-year average.†	Fair value.	Hist. repro. cost.
Depreciation method	Sinking fund.	Straight line.	No standard.	As warranted.
Obsolete by inefficient	Balance amortized	Excluded.	Excluded.	Excluded.
Cost of financing	Operating cost.	No.	Computed.	For bonds.
Going value	Included.	No.	On merit.	As prelim.
Original cost depreciated	Orig. not used.	Orig. not used.	No.	Yes.
4—Common rate of return	8 per cent.	8% (N. gas = 10%).	7 per cent.	6 per cent.
5—Annual depreciation allowance—				
Method computed	Sinking fund.	Straight line.	No standard.	As warranted.
To create actual reserve?	Yes.	Intended.	Not intended.	Intended.
Is reserve part of rate base?	Yes.	No.	Not intended.	No.
6—Are reports required?	Yes.	Yes.	Soon.	Yes.
7—Operating expenses—				
Is efficiency rewarded?	Yes.	No.	Law provides.	No.
Commission to decrease rates with operating costs?	Yes.	Not usual.	Close scrutiny.	If desirable.
8—Can new rates become effective without Commission permission?	No.	As prescribed.	As prescribed.	No.

Note.—All practice is subject to requirements of the case. *With certain minor exceptions. †The law provides "As of a date certain."

we are very pleased to discover a growing recognition in that direction.

We desire to acknowledge, at this time, that the table herewith has been prepared through the kind assistance of the chief engineers to the commissions, for the states quoted, and in this connection we would point out that the actual tabulation is an interpretation by the writer from written discussions by its chief engineers, to the end that the result here shown may not always be a fair interpretation of the average practice of the commission in question, and regarding many of the items, they certainly do not represent inflexible rules of such commission.

Particular Feature of Commission Practice.—We would direct your attention to some particular feature of the practice for each state as indicated by Table I.

Indiana.—The specific 10 year period used by the Indiana Commission, to determine plant value, is not considered by them as conclusive and is used with judgment. The law provides that all pertinent information may be considered. With respect to going value, the law says, the cost of bringing the property to its then state of efficiency shall be considered.

Ohio.—The law states that the moneys in the depreciation fund may be used for extensions, etc., or if invested, the income from the investment shall also be carried in the depreciation fund. The latter part of this statement is in keeping with the sinking fund theory of depreciation and with the theory of retaining the depreciation fund in the rate base, although neither of these ideas are followed by the Ohio Commission in this way.

Pennsylvania.—The practice of the Pennsylvania Commission in considering original cost, undepreciated, is in keeping with the idea of retaining depreciation reserve in the rate base, but the idea is not carried beyond this point by the Pennsylvania Commission.

West Virginia.—If original cost is used by the West Virginia Commission as the basis for plant value, it is depreciated in the same way as for reproduction cost estimates. The practice, for said state, of intending that there shall be an actual reserve fund, together with the practice of not considering this reserve fund a part of the rate base, means that the reserve fund shall provide its own revenue for the purpose of paying a return to the stockholder for that portion of his investment.

Source for Incentive in Commission Rulings.—Looking now for a source of incentive, and on reference to the table, under Item No. 3, we find no reward, offered by any of the commissions, for the replacement of inefficient plant items. Indiana intends that the company be permitted to amortize the remaining value in such replaced equipment, but for other states where the company is even penalized, the plant manager might often continue the operation of inefficient equipment, rather than lose credit for remaining investment in same.

Under Item No. 7 we find some food for thought, as related to the present subject, and we find that one commission does recognize efficiency. The Indiana Commission rewards efficiency and economy by permitting a higher rate of return where such conditions exist, than where conditions are less commendable.

In this connection we might add that the North Dakota Commission has recently said:

"That a company which is on the alert to practice economies should have some part of the saving, else there would be no inducement to reduce the cost of service."

The West Virginia Commission has voiced a corresponding idea regarding incentive, although with respect to value of water rights, and we quote only that part of the opinion which especially incorporates the idea of the subject at hand.

"The investors are entitled to a return upon their foresight and their enterprise—Otherwise, there would be no incentive for the exercise of initiative and vision—In fixing the value of water power the Virginia Commission allowed the company a sum, on account of its water rights, which approximately divided the net saving, due to the use of the water company's water power, between the company and the public."

Efficiency and Economy Recognized by Commissions.—It is unnecessary therefore, to say that efficiency and economy should be recognized but we can say instead that efficiency and economy are being recognized by many commissions. It must be remembered, however, positively, that a public utility must submit full evidence as to economies and efficiencies before it can expect the commission to recognize the same. The commission sits as a court to hear the case, and not as lawyers or engineers to present or develop a case.

Possibly the Pennsylvania Public Service Commission law holds the key to the situation, where it provides:

"That it shall be lawful for every Public Service Company....to participate, to such an extent as may be permitted by the commission, and deemed by the commission wise, for the purpose of encouraging economies, efficiencies, or improvements in methods of service, in additional profits which will be afforded by such economies, efficiencies or improvements in methods of service."

Which, for clarification might be read as follows:

"That is shall be lawful for every Public Service Company—to participate in additional profits which will be afforded by economies, efficiencies or improvements in methods of service, to such an extent as may be permitted by the commission and deemed by the commission wise, for the purpose of encouraging such economies, efficiencies or improvements in methods of service."

Reward for Economy and Efficiency.—We are now at the real nubbin of this problem, which is with reference to a practical effective method of making a division of the extra profits which may be created by economies and efficiencies.

As each commission might initiate and adopt this idea of "Reward for Economy," they would probably also feel quite capable of defining the methods to be used. From a glance at the table herewith, we may reasonably conclude that each commission would adopt a different policy, at least as to detail, and if we are to have any uniform idea of method used by different states, it is evident that some centralized body must do the missionary work as to standardization.

The speaker realizes how futile it may be to offer suggestions which do not yet have sufficiently general support to insure success, but if no suggestion is made, as to a possible or practical solution, we then have left the subject of this paper suspended in midair. The practical solution in the case at hand might be the establishment of "standards of cost" to serve as a guide in fixing any rewards, and such standards would also surely serve to encourage operators of municipal plants.

"Standards of Cost" as Guides.—This might mean that some centralized body would establish standards of cost for each of the various operating expenditures of a utility department with which the similar costs, for the case in question, might be compared, and for this work of standardization there is certainly no organized body nearly so well prepared to do such work for water plants as the standardization council of the parent body of this organization. This would mean that the standardization council should create an additional permanent committee, the members of which should be anxious to put their heart and soul into such work in order to make the idea a success.

The question naturally arises as to how much such activities would be beneficial to municipal plants, and we will here only point out the possibility offered by such "standards of cost" through the impression which is made on the management of the municipal plant. This would offer a standard for comparison, widely known to all active utility men, and public officials, a standard by which any utility man could compare his operating costs, and the knowledge that he was either above or below such a standard might spur him to greater efforts, as well as standards for comparison of costs by the chief executive of the municipality in question, which in turn would cast reflection or credit upon the official in charge of such a department; thus creating a positive incentive for economy as affecting either the pride of the manager or the security of his position.

If such an activity be organized in a practical way, resulting in reliable data, it would certainly offer possibilites as a guide for public service commission activities, and with the idea that the public utility and its patrons should share, and share alike, from any economics effected, we certainly would gradually obtain results as follows:

1. To save money for the patrons of many public utilities.
2. To increase the net revenue for many public utilities.
3. To provide standards of cost towards, and below, which all operators could strive.
4. The correction or removal of a fundamental ailment, namely, "Lack of Incentive for Economical Operation."

Hydrogen Ion Concentration and Water Purification

Use of Hydrogen Ion Measurements in Connection With Water Purification at Cedar Rapids, Ia., Described in Paper Presented Nov. 3 at Annual Meeting of Iowa Section of American Water Works Association.

By F. C. MORTENSEN,
Professor of Chemistry, Coe College, formerly Chemist Cedar Rapids Water Department.

Work was begun at the Cedar Rapids plant in the summer of 1921 under the direction of Mr. J. J. Hinman of the State Board of Health at Iowa City, to determine if proper control of coagulation, sedimentation, filtration and chlorination, a better quality of water could be produced and at less expense.

A small settling basin was built which has proven its worth. The short time given for coagulation and sedimentation has increased the efficiency of the filters and improved the quality of the water. The basin was first used on Feb. 2, 1922, consequent to a succession of heavy rains which brought from Cedar Lake the highly colored water into the river. The usual method of treatment of dosing with alum in excess with a moderate amount of lime, served only to make matters worse in that the color was "set" with the production of a milky effluent. The residual aluminum compounds in the water effluent gave us many complaints as to taste and since then to the corrosive effects on the plumbing.

Laboratory tests showed that the water became more highly colored as it passed through the basin due of course to the solution of the tannetes and gallates from the new timber of the basin. Tests also showed that if the bicarbonate alkalinity could be lessened that better results could be obtained. We then began to decrease the alkalinity and found that the water must be acid. The exact acidity we found to vary, but that a hydrogen ion concentration of 5.6 gave results. With the passage of the colored water the proper P H for the water in the settling basin was found to be about 6.5. This is in agreement with Longley's findings that the removal of color the alkalinity should be low. During this period of colored water, the river water was almost free from bacteria due to the mutual precipitation of the positively charged color and the negatively charged bacteria.

A few weeks after the above mentioned colored water had passed the ice in the river broke up with an increase of turbidity. Eight grains of alum per gallon were added to a water with a turbidity of 700 P.P.M. and an initial PH of 6.6. Precipitation was effected and settlement was rapid, leaving the water clear and with a final PH of 6.0.

The Isoelectric Point.—It therefore seemed important that the proper charge be kept on the alum to bring about the effective removal of color or turbidity. For the removal of color the alum must be negative while positive for the removal of turbidity. It has been generally held that alkalinity is the factor which governs the precipitation of the alum, but certain experiments indicate that there is an optimum point at which all of the aluminum hydroxide is precipitate, and that above which point on the alkaline side and below which on the side of acidity the precipitation is not complete. The reaction (1)

$$Al_2(SO_4)_3 + 3CaCO_3 . H_2CO_3 \rightarrow 2Al(OH)_3 + 3CoSO_4 + 6CO_2$$

or $Al^{+++} + 3HCO_3 \rightarrow Al(OH)_3 + 3CO_2$. is so simple that it has become generally held that if the coagulum $Al(OH)_3$ is not instantly and continually formed the treatment is either careless or faulty. In effective floc formation and residual aluminum hydroxide in filter effluents even with plenty of raw water alkalinity is probably due to other causes than poor control. Two explanations are proposed for the resolution of the aluminum hydroxide, one that it is due to variations in the chemical combination, (2), the other that resolution is due to peptisation (3). There is experimental evidence for both explanations and it is clear that the presence of Hydrogen or Hydroxgl Ions gives us a basis on which to predict whether or not a change will take place. In the case of amphoteric *hydroxides such as aluminum hydroxide an excess of alkali is to be avoided. It, therefore, becomes desirable to select that degree of alkalinity which will insure most complete preciptation and at the same time avoid resolution of the precipitate. Blum (4) states that the precipitation of aluminum hydroxide begins at a P H of 3 and is complete before a P H of 7 is reached in the vaction of Sodium hydroxide on aluminum chloride. He finds that from a P H of 7 to a P H of 10.5 that resolution of aluminum hydroxide in sodium hydroxide is increasing in action until at the latter point the solution is almost complete. Cabengl believes that lime acts (as follows)

$$Al_2(SO_4)_3 + 6Ca(OH)_2 \rightarrow Ca_3Al_2O_6 + 3CaSO_4 + 2G_2O$$

suggesting that calcium aluminate rather than aluminum hydroxide is in the colloidal state and that the size of the particle may be regulated by the degree of alkalinity of the solution. Hildebrand shows that aluminum hydroxide is precipitated by sodium hydroxide even when the aluminum sulphate is strongly acid. Stieglity explains that aluminum hydroxide may ionige.

$$\overset{+++}{Al} + 3\overset{-}{OH} \rightleftarrows Al(OH)_3 \rightleftarrows Al\overset{-}{O_2}\ \overset{+}{H}\ H_2\overset{-}{O}$$

accordingly as it reacts with acids or alkalies at the isoelectric point. This isoelectric point (5) has been defined as the point of maximum precipitation, minimum solubility, minimum viscosity, minimum swelling optimum agglutination, no migration under the influence of the electric current.

To determine the isoelectric point or aluminum hydroxide in various alkaline solutions 10 mgs. of aluminum sulphate were added to a liter of distilled water in an Imhoff cone. The alkalies sodium hydroxide, sodium carbonate, sodium bicarbonate and lime water were prepared containing 10 p.p.m. of available alkali. The alkali was added in one half c.c. portions, stirred well and allowed to stand exposed to the carbonioxide of the laboratory to settle for three hours. The amount of aluminum hydroxide precipitated was read in c.c. and plotted against the PH at that time. The P H was determined by the caloumetric method as outlined by Clark and Lubs. Solutions were prepared as directed and checked against solutions made according to the direction of Sorensen.

In all cases the precipitation began at a P H of 3 and resolution was complete at a P H of 10.5. Precipitation and resolution was most rapid for the lime. Precipitation was complete for the lime at a P H of 6.6, sodium hydroxide at 6.8 and for sodium carbonate and bicarbonate at 7.4. While these results indicate that the isoelectric point is near 7.0 it would appear

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[1] Chem. and Met. Eng., April 27, 1921.

[2] Hatschek, "An Introduction to the Physics and Chemistry of Colloids."

[3] Getmar, "Introduction to Physical Chemistry."

[*] Amphoteric hydroxides are compounds which are basic or alkaline in their action with acids and acid in their reaction with bases or alkalies.

[4] Chem. and Met. Eng., 24:728.

[5] Clark, "The Determination of Hydrogen Ions."

[6] Bulletin No. 16, Ill. State Water Survey.

[7] J. Phy. Chem., 24:630.

that the difference in results is due to the effect of the ions. Some work was done as to the influence of various salts on the precipation value of aluminum hydroxide and the results indicate as did the work of Smith (6) on Silicic Acid and Weiser and Middleton (7) on the precipitation values of potassium salts on Hydrous Alumina Oxide that each ion of the salt as well as the salt itself influence the P H and therefore, the precipitation value. The raw water during the greater part of the year has an P H of 7.0 and after alum treatment is between 6.6—6.8. This clears well in the settling basin. The water coming thru the filters has a P H of 7.0. When the P H of the water in the clear well was kept at 7.0 or lower before chlorination better results were noted in bacterial removal. This as Rideal and Evans explain is due to the fact that acid waters have a higher oxidizing power than do alkaline waters.

It has been our experience that following the breaking up of the ice and the heavy April, June and October rains that as soon as the hardness drops below 100 P.p.m. that the corrosive property of the water increases very noticeably. At such times the addition of lime after filtration to the clear well has decreased this source of complaint.

The determination of the hydrogen ion concentration of our water has given us a more satisfactory method of control than the alkalinity titration method in that we know the P H which will give the best floc formation in our settling basin, the most complete residual aluminum hydroxide removal by our filters and the greatest oxidizing power of the chlorine.

Pipe Line Suction Dredge Towed 281 Miles

The Panama Canal has sold its 20-in. pipeline suction dredge No. 84 to a contracting company, and has delivered it to Cartagena, Colombia, where it is to be used in deepening a channel to the Magdalena River.

The dredge was towed from Cristobal to Cartagena, a distance of 281 miles, by the Panama Canal tug Tavernilla, without being knocked down or otherwise dismantled, and arrived at Cartagena with steam up in one boiler, ready to go to work. The dredge is 124 ft. in length by 36½ ft. beam, built on a rectangular hull, with a superstructure of two stories, the crew being quartered and subsisted on the upper story. The depth of the hull is 9 ft., and the draft about 4 ft. In preparation for towing the sides were boxed in, at Crostobal shops. The tug used a towing hawser of 1,000 ft. The time of towing was about 43 hours, to reach the breakwater at Cartagena, and 8 hours later delivery had been completed and the tug was on her way back to Cristobal. The return was made in 26 hours. Good weather was encountered throughout.

The towing of a vessel of the type of the dredge, for such distance in the open sea, without dismantling any of the equipment or structure, states the Panama Canal Record, is said to be something that was never accomplished before.

357 Applications, Involving 21,100,000 Hp. Filed with Federal Power Commission

During the second year of operation applications aggregating a net total of 5,000,000 HP. or proposed installations were filed with the Federal Power Commission. This amount added to the applications in a preceeding year brings the grand total of applications received to 357, involving in excess of 21,100,000 HP. This amount, recording to the second annual report of the commission, made public in November 25, is more than twice the existing water power installation of the United States, and more than six times the aggregate of all applications for power sites under Federal control in the preceding 20 years.

Nearly one-half of the aggregate of 200,000 HP. is represented by applications upon the St. Lawrence, Columbia, and Colorado Rivers, upon which in genral action has been suspended. The St. Lawrence involves international relations and may require a treaty before action can be taken. The Columbia has been under investigation by a special board to determine, before applications are approved, the relation between water power, irrigation, and navigation upon that stream. Action on the Colorado River is awaiting the findings of the Colorado River Commission, an organization authorized by act of Congress for the purpose of negotiating between the States within the Colorado basin a compact in accordance with which the waters of the river may be apportioned among these States.

By confining its activities primarily to applications for power projects, declarations of intention, and requests for restoration to entry the Commission has been able to take final action on more than half of the applications filed during the two years.

Up to June 30, 1922, the Commission had authorized 58 preliminary permits and 49 licenses, of which 18 were for transmission lines: The 58 permits now outstanding involve an estimated installation of 2,405,975 HP. and the 31 licenses for power projects 1,945,245 HP. or a total of 4,351,220 HP. Of the projects covered by the 31 licenses, 27, involving an estimated installation when completed of 1,951,800 HP., were either completed or under construction at the close of the fiscal year. This is 30 per cent. more than was constructed under Federal authorization in the 20 years preceding the passage of the Federal Water Power Act. The Commission also rendered decisions during the year upon 22 declarations of intention, passed upon restorations to entry in 163 cases, and made withdrawals of 675,000 acres of public lands in connection with applications for power projects.

Water Mains Under Railroad Tracks

Some interesting points in the above subject were brought out in a topical discussion at the last annual convention of the American Water Workers Association. The notes following are taken from the November Journal of the Association.

D. R. Gwinn.[1]—The Pennsylvania Railroad tracks ran over some 6 in. pipe. laid about 40 years ago, and we adopted a plan, whenever we had a leak to dig up, of putting on one of those extra heavy flange sleeves. I think the flange must have been 1¼ in. thick and a large enough sleeve to cover the bell. That seemed to be the most effective remedy we were able to use. We tried making a little tunnel on a small scale, that is, building a wall on either side and covering it over with reinforced concrete slabs. If it were of any particular length, we would fix the ends of the joints so that one would lap over the other, so the dirt would not sift through, but the best success we had was with this extra heavy sleeve. You have actually, outside of your original joint, the other two joints and you can make them as heavy as you please by pouring them solid with lead if you like.

J. E. Gibson.[2]—Under railroad tracks, we have adopted the policy of laying another pipe just about the length of a cross tie, and then passing the water pipe through that and making all joints between tracks, so that if we do have a leak we can get down, as a rule, without undermining the track. If there is a breakage in the pipe passing through the outer conduits, which we have never had occasion to experience, we may substitute a new pipe without undermining the track again. This is a little more difficult but it can be done. The outside pipe simply takes the vibration off the water main, and we have found that to be effective.

W. Luscombe.[3]—We have gotten rid of a great deal of trouble with water pipes under crossings by putting the pipe under the railroad deeper than ordinarily. By placing them 8½ to 9 ft. deep, we found the vibration much less and our first leak is yet to occur. Of course the city is rather new, but after 15 years we have not yet had one leak under railroads. We adopt also the plan of having the joints come between the tracks so as to make them more accessible for repairs.

W. C. Hawley.[4]—Twenty or twenty-five years ago an old 8 in. cast iron main passed under the railroad and we had to dig down frequently to those joints and recaulk them. That was before the days of leadite. We have replaced the lead with leadite and have had no trouble since. The heavy Reading trains come in and, as they go over the thoroughfare, they put on their brakes, so that is a pretty good test of that joint.

Assistant Engineer (Irrigation and Drainage).—The U. S. Civil Service Commission announces an open competitive examination for assistant engineer (irrigation and drainage). A vacancy in the Indian Service at Large, Albuquerque, N. Mex., at $1,680 a year, plus increase granted by Congress of $20 a month, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries, will be filled.

Delaware River Channel 73 Per Cent Completed.—The Federal Project for dredging 35 ft. channel in Delaware River was 73 per cent completed on June 30.

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[1] President, Water Co., Terre Haute, Ind.

[2] Superintendent, Water Department, Charleston, S. C.

[3] Vice-President, Gary Heat, Light & Water Co., Gary, Ind.

[4] Chief Engineer and General Superintendent, Pennsylvania Water Co., Wilkinsburg, Pa.

Railways and Excavation Issue

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Roads and Streets—1st Wednesday
- (a) Roads
- (b) Quarries and Pits
- (c) Streets
- (d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
- (a) Water Works
- (b) Irrigation and Drainage
- (c) Sewers and Sanitation
- (d) Waterways

Railways—3rd Wednesday
- (a) Steam Railway Construction and Maintenance
- (b) Electric Railway Construction and Maintenance
- (c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
- (a) Buildings
- (b) Bridges
- (c) Harbor Structures
- (d) Miscellaneous Structures

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Terminal Consolidation As a Field for Railroad Economy

Any intelligent and unprejudiced person must realize that the problem of railroad economy is not the simple one so often stated or intimated by writers and speakers without practical knowledge of their subject. That economies are possible, there is neither doubt nor denial, however much the actual opportunities may fall short of the imaginary.

One of the most promising fields, it appears to us, is that of terminal consolidation and co-operation. Usually competing terminals involve a large duplication of valuable property with interest, maintenance and tax charges for each competitor largely exceeding what would be a fair share under a joint arrangement. While failure to consolidate in the past, where consolidation was a physical practicability, has usually been due to the advantage which one road or another considered that it had over its competitors, and its consequent refusal to make operating terms with its rivals, it is fair to ask if there have not been numerous over-estimates of these advantages in securing additional business or otherwise, and if many a road might not have been the gainer by granting a suitable joint terminal arrangement—even to competing lines. Likewise, it is not improbable that the less fortunately situated road could have paid a price which its competitor would have accepted for the use of its terminals, and still have remained a financial gainer at the end of a suitable operating period. Certainly the public and one road or the other would have been the gainer from a consolidation in many cases; and in by no means a small number, all the roads would have profited.

In spite of the handicaps under which they have long labored, the railroads are having to improve or expand their facilities in many places, and these are the cases which afford the greatest opportunities for consolidation. If huge sums are now expended in avoidable duplications the public will take it as a further evidence of insincerity in the claim that the purpose of the roads is public service.

The Railways and the City Plan

In the city plan, the location of lines and termini of railways are matters of prime importance; and the importance of the city plan to the railways, while less obvious, has not escaped recognition by able railroad executives. A meritorious plan will not provide for the relocation of railway lines and terminals simply because a better location is conceivable, but in conformity with its broad economic function, it will give all due consideration to the cost of changes, abandonments, and new construction, and will undertake only such work as has a demonstrable advantage.

In many instances it will be desirable to keep the railways where they are with little or no change. In others, important changes will be necessary, their costs being assessed to the community in the same fashion as the cost of changes and damages to other sorts of private property. The railway, of course, should bear its share of community costs and receive its share of public benefits: and while the net gains to the railway, as to any other individual interest, will be subject to wide proportionate variations on different projects, on any well considered project they will be real and demonstrable.

In some instances relocation will take the place of expensive reconstruction on the old sites with great ultimate advantage to the roads. In other cases there will be savings in operating costs which will pay for the changes within a reasonable period of time, although such changes might never have been made except for the stimulus of the city plan. Demonstrable losses or injuries will receive compensation. Under any good city plan the advance in community prosperity will bring an increase of business to the railways, as to every other industry, and it is logical that the roads should take an active interest in promoting and securing the execution of projects of this character.

Present and Prospective Development Cost of Railways and Other Public Utilities

By HALBERT P. GILLETTE, Editor.

For the purposes of this article development cost is the accumulated deficit in "fair return" on an investment where such deficit is the result of building up a business to a point at which a "fair return" is realized.

The U. S. Supreme Court has very recently decided adversely to a development cost based on the early history of a plant. This was to have been expected, for the Supreme Court had repeatedly ruled against the actual cost of a utility plant as a base for rate making, and it followed logically that the actual development cost (or cost of the non-physical property) could not be used as a base for rate making if the cost of the physical property were rejected.

The writer was the appraiser for the Galveston Electric Co. in a case that was carried to the Supreme Court in the effort to secure an increase in the street car fares in Galveston, and it was in this case that the Supreme Court ruled against a development cost based on the early history of the street railway. The writer had testified that this early development cost was to be associated only with the actual cost of the physical plant, but that even today a development cost would be incurred in building up a business of a similar character, and that such a present or prospective development cost would fully equal the accrued depreciation in the Galveston street railway system, which was about 25 per cent. The master who heard the case in the lower court decided in accordance with this testimony, but the Federal judge overruled the master and excluded all development cost, basing his argument entirely on the irrelevancy of the early development cost. The Supreme Court upheld the lower court, but made no reference whatever to the testimony as to present development cost. It seems to the writer that the Supreme Court either failed to notice the testimony on present development cost or failed to be impressed by it. Both the appraiser who represented the city of Galveston and the writer (representing the company) submitted testimony as to the early development cost in regard to the amount of which they were in substantial agreement. Their testimony on this subject covered many pages of the record, and included several long tables. Whereas the testimony on present development cost, to be associated with present cost of reproduction, was very brief and unsupported by data.

In preparing for a new trial, the writer wished to go into much greater detail as to present development cost, but was confronted by the difficulty of securing adequate data. The so-called Alvord method of calculating development cost, as described on pages 46 to 49 of the Handbook of Mechanical and Electrical Cost Data, by Gillette and Dana, has never seemed tenable to the writer for reasons given in that Handbook. It involves the assumption that there is no plant but that there is a city of the present population with its present habits ready to begin using the plant upon its completion. In the case of a street railway, this would result in its being used by the public, just as they now use it, as soon as it was ready for use, thus creating little or no development cost.

To overcome this defect of the Alvord method, the writer suggested that the hypothetical new plant should be assumed to enter into competition with the existing plant. But the writer has had occasion to appraise only one plant—a gas company—in which this method did not give a ruinously high development cost. So the writer was forced to reject the competitive plant method of calculating present development cost as one that could be generally applied.

Only three development cost methods have been published, namely, (1) the Wisconsin method (i. e., early development cost method); (2) the Alvord method (i. e., hypothetical new plant without competition in the existing city), and (3) the Gillette and Dana method (i. e., hypothetical new plant competing with the existing plant), but all three fail of generality. Can any method, other than a pure "hunch method," be devised? The rest of this article is an answer to this question.

In every normally growing community in America, nearly every public utility plant makes extensions of its plant to meet the demands of people who want its service. As almost any railway manager can testify, it is rare that an extension of track yields enough additional revenue to pay operating expenses and a fair return upon the cost of the extension, for several years after the completion of the extension. Hence by investigating the economic results of recent extensions it becomes possible to deduce the development cost of each extension up to date, and, where the deficit in fair return has not yet ceased, to estimate approximately when it will cease. Based on such data as to development cost of extensions made in the recent past, the present and prospective development cost can be estimated quite accurately. From these results there can be derived percentage relations between the investment in each recent extension of the plant and its development cost. In this way it becomes possible to estimate present and prospective development costs without resort to guessing.

In the case of plant enlargements of any kind for the service of new customers or for increased service of old customers, it is possible to estimate approximately the development cost of the enlargement. The writer believes that nearly every public utility company should begin to study the development cost of all important extensions and enlargements made during the past few years. Such information will prove valuable not only in rate cases, but in deciding upon the wisdom of future extensions or enlargements.

About the only technical difficulty encountered in such a study is that arising from allocation of joint costs. Few men have given much study to the principles of such allocation. On pages 51 to 58 of the Handbook of Mechanical and Electrical Cost Data will be found a discussion of this subject, the conclusion being that the only perfectly general method of prorating joint costs is the Separate Plant Theory of Allocation.

Although having only incidental bearing upon the subject of this article, it may be of interest to know that the writer and his associate, Mr. J. C. Black, had prepared a new appraisal and operating expense analysis for presentation to the court Oct. 30 this year at the trial of a new case brought by the Galveston street railway company, but that the case did not come to trial because the city of Galveston, which for more than two years had fought an increased car fare, at the last moment decided to grant a 6-ct. fare. If a 6-ct. fare is just today, more than 6 cts. was just two years ago when prices and wages were almost at their peak.

It was then predicted by the writer that the "new plateau of prices" would be about 66 per cent above the level of the year 1913. The federal judge decided that 33 per cent would probably be nearer than 66 per cent. As a matter of fact the appraisal of the Galveston street railway system as of June 30, 1922, gave a cost of reproduction about 70 per cent above the prewar cost of the corresponding price plant. The general wholesale price level was 53 per cent, and the wage level 65 per cent above the prewar level.

The street railway company has suffered a heavy deficit during the past two years as a result of its inability to secure a 6-ct. fare sooner. But there appears to be no legal redress for losses thus incurred during litigation and prior to a new trial.

Early Start on Railway Construction

Editorial in Railway Age.

While at first thought it may seem premature to suggest the consideration of next year's construction program at this time when the present season's work is not yet completed, several roads are already making detailed plans for their 1923 activities. This year has witnessed the gradual resumption of the improvement of existing facilities. On some roads the amount of work undertaken has even approached that of boom years. The heavy traffic with which the roads are now struggling has demonstrated the shortcomings of existing facilities very forcibly and it is to be hoped will soon begin to provide more net revenues from which improvements can be financed, so that the indications point to 1923 being an active year.

The railways have been out of the construction field so long that the organizations to which these activities have given rise in the past have disintegrated in large measure. Few roads have sufficient engineering forces to do other than the minimum amount of work and the experienced locating and construction engineers in their service are few in number. Even more serious is the lack of large contractors' construction organizations familiar with the requiremnts of railway work. Many of the railway contractors of former days have entered the field of highway construction, while others have gone out of business because of the lack of contracts from the railroads.

It is because of these conditions that the more alert roads are already working on detailed plans for next year. The engineering department of one road has secured authorization for more than 20 million dollars' worth of improvements and is now preparing plans and specifications preliminary to calling for bids. Other roads are scarcely less active. By calling on contractors for bids on their projects soon these roads will not only be prepared for an early start next spring and secure the use of the facilities quickly, but they will also secure first call on the available contractors.

Whenever activities are resumed on the scale which the present inadequacies of railway facilities demand, there will be a shortage of experienced railway and contractors' organizations which will limit the amount of improvement work which can be completed economically and will lead to competition for service which cannot but add to its cost. The road which anticipates this condition and contracts its work early will be in the same favorable position as the railway which buys its materials in advance of its associates.

Organization in Railroad Work

Editorial in The Canadian Engineer.

Convincing demonstration of the necessity of high personal efficiency in railroad work was given in a recent address by R. N. Begien, general manager of the Baltimore & Ohio R. R., before the American Railway Bridge and Building Association. The speaker pointed out that if a 90 per cent general superintendent selects a 90 per cent superintendent and he selects a 90 per cent division engineer, who employs a 90 per cent supervisor, who hires a 90 per cent foreman and 90 per cent men; the result is an overall efficiency of only 53 per cent. However desirable 100 per cent efficiency of the individual may be, the performance of the whole organization can not be materially improved unless all co-operating officials and workmen are also 100 per cent efficient. To ensure that the proper conditions exist for high efficiency of an organization, the general officers must above all else themselves possess the highest possible efficiency.

Another point of importance to organization in general was made by Mr. Begein in the assertion that an organization composed of all-star members is likely not to produce such an excellent result as one composed of members of average ability working thoroughly in accord with each other. It is a well-known principle of organization that experts and genuises do not perform so well in line appointments as on staff duty. They are not so easily adjustable to the mechanism of an organization and frequently are incapable of acting according to a preconceived and thoroughly matured plan of operation. Persons who insist on following out individual whims of the moment cannot be trusted to carry out important policies in an organization. Their value to an organization lies not in seeing that others perform duties in exact accordance with a preconceived plan, but rather in the devising of new and original plans which some one else of a different temperament will be asked to put into effect.

Of great significance was the element of Mr. Begien that the personnel of an organization is of more importance than the organization itself. The persons who make up the force should be the last to be disturbed. An organization is of necessity a changing thing which has to be modified in accordance with the kind of people obtainable to carry out the policies of the management. The scheme of operating must necessarily be shaped to suit the particular human material available for the enterprise.

Highway Dips for Preventing Grade Crossing Accidents

To the Editor: I always read with interest any article pertaining to the improvement or elimination of the grade crossing and the many articles written about it and the newspapers' accounts of the death toll at such crossings leads me to suggest an innovation which, I believe, would decrease the number of accidents materially.

What I have in mind is a series of "dips" in the highway on each side of the railway tracks—say two such dips, one located about 50 ft., the other about 150 ft. from the outside track. These distances could be altered to suit conditions or could probably be placed more effectively by experiment.

These "dips" could be made about 18 in. deep and about 10 ft. from beginning to end, making a smooth gliding dip for cars traveling slowly, as they should at crossings, and making it rather rough for speedsters who will naturally slow down when they know such an obstruction exists and who will slow down for their own riding comfort sooner than they would if they are trying to beat a train over the crossing.

While it is economically impossible to eliminate grade crossings entirely with overhead or underhead crossings, the remedy I suggest could be quickly and without great cost, be installed in any highway already built or under construction both paved and unpaved.

I am aware of one city in the West which has carried out this idea effectively, not in respect to railway crossings but for cross streets crossing some of the main thoroughfares leading out of the city and where the view is obstructed by shrubbery and residences; the dips also served as gutters here and they were certainly effective means of slowing down reckless speedsters traveling in a normal direction to that of the most traffic.

Another argument in favor of such a crossing is that even drivers under the influence of intoxicants would remember that the dips were there. Especially after he had hit the first one he would naturally slow down in order not to injure his car on the next.

A suitable sign could be placed at a convenient distance informing the driving public of the dips.

Sardis, B. C. A. R. HIPKOE.

Tie Preservation on Pennsylvania R. R.—Nearly 6,000,000 cross-ties received a preservation treatment preparatory to being placed in tracks of the Pennsylvania Railroad last year, according to a report just compiled by John Foley, forester for the system.

Motor Vehicle Transportation in Relation to the Railways

Report of the Committee on Motor Vehicle Transportation of the National Association of Railway and Utility Commissioners Made at the Annual Meeting of the Association at Detroit, Nov. 14-17. E. V. Kuykendall, State of Washington, Chairman of the Committee

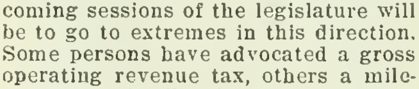
Many difficult problems are encountered in determining whether public convenience and necessity justifies the granting of certificates to stages and trucks operating in competition with railroads. It should be the purpose of all regulatory bodies to coordinate the various transportation systems of the country in such manner as to render the best service to the public with the least injury to established rail and boat transportation companies. It must be conceded that the country is dependent upon the rail lines for the transportation of passengers and heavy freight over long distances. It is also clear that auto truck transportation meets a public demand in the rapid transit of less-than-carload shipments, including the door-to-door delivery element which the railroads have thus far failed to furnish. The railroad companies have exhibited a degree of indifference or slowness bordering on stupidity in recognizing and meeting the demands of the public for quicker and more convenient movement of less-than-carload freight. Rather than provide light equipment and quick movement, they have relied too much upon securing protection from the regulatory bodies of the various states against truck competition. We believe it evident that if the rail carriers hope to retain their short haul freight traffic, it will be necessary for them to make radical changes, both in service and equipment. Trucks are now rendering an astonishing service between shopping centers and outlying traffic points. Country merchants prefer direct truck service to the railroads even where the cost of the service is equal, for the reason that the trucks call at the wholesale house, receive the commodities desired and unload them at the store doors. This enables the country merchants to conduct business with a smaller stock of goods, for the reason that new supplies can be obtained conveniently and on short notice through truck service. Truck service is also preferable in the movement of household goods from one town or city to another, there being no need for crating.

It is impossible to lay down any general rules of much value to be observed by regulatory bodies in granting certificates of public convenience and necessity in competition with rail service. Each case must stand largely upon its own bottom. One element which might properly be considered in determining public convenience and necessity is the popular demand for particular service. If truck and stage service are ultimately to supplant short haul service, the process in the very nature of things must be slow and gradual. Oftentimes petitions signed by substantially the whole community are presented demanding the truck or stage service. While such petitions are of doubtful evidentiary value, for the reason that the average citizen will sign a petition without much thought or deliberation, they are usually received as having some bearing upon the question of public convenience and necessity. In cases where the demand for the truck or stage service is practically unanimous and insistent, the applications should ordinarily be granted, unless it would result to the detriment of the community by the curtailment or stoppage of train service. On the other hand, it sometimes occurs that the community where a stage or truck certificate is sought, is against the granting of the application and petitions opposing it are filed. In such cases the applications might properly be denied, for the reason that the regulatory body should not assume the attitude of imposing upon a community a service which is not desired. We do not wish to convey the impression, however, that stage or truck service should be permitted in every instance where popular sentiment seems to demand it. There may be other conditions which would outweigh the element of popular demand.

There is a general feeling, particularly in the western states, that motor transportation companies should be required to compensate the state in some way for the wear and tear of the highways over which they operate. In fact we feel that the tendency of the coming sessions of the legislature will be to go to extremes in this direction. Some persons have advocated a gross operating revenue tax, others a mileage tax, and still others various other modes of raising revenue, including the gasoline tax. If any scientific study or investigation has ever been made for the purpose of determining what would be a just form and amount of tax to impose upon motor transportation companies, we have no knowledge of it. We doubt very much if it would be possible to conduct an experiment or make a calculation that would be of much value to a legislature. The gasoline tax, in our opinion, is the most equitable method. It takes more gasoline to propel a 10-ton truck than a Ford. This tax is easily and cheaply administered.

Special Trailer for Moving Power Shovel in City Work

A trailer of unusual design has been built for E. Schilling, a contractor of Los Angeles, Calif., for moving his 30-B Bucyrus shovel around the city. Mr. Schelling has done a considerable amount of basement excavation and general dirt-moving work in and around Los Angeles, and has been using this trailer to great advantage in moving his caterpillar shovel from one job to another. We are indebted to The Excavating Engineer for the following particulars of the trailer.



Trailer for Revolving Shovel.

Although this shovel is mounted on caterpillars and is in itself very mobile, it has been found that this device saves considerable time in making frequent long moves from one small basement excavation to another. No blocking is necessary for loading the machine. When ready to move, a pin on the front truck of the trailer is removed, the trucks pulled out of the way, and the front end of the I-beams allowed to rest on the ground. The shovel is then run under its own power a few feet backwards on to blocking at either side of the trailer I-beams. The front trucks of the trailer are then put in position and coupled up, after which the caterpillars are propelled forward, and the truck pulled forward at the same time until the caterpillars are off the blocking and the weight of the shovel is taken by the trailer. When loaded, the base of the machine rests on the trailer I-beams with the caterpillars overhanging at either side and clearing the ground by about 6 in. The shovel can be loaded in this manner in about 15 minutes.

Fields of Rail Car, Trolley Bus and Gasoline Bus

Respective Advantages of Three Methods of City Transportation Considered—Rail Cars Best for Headways of 3 Min. or Less—Trolley Bus for Headways of 6 to 60 Min.—Gasoline Bus for Headways of 1 Hour or Over.

Although used fairly extensively in England, Germany and Austria, the trolley bus is a new development in transportation on this continent. During the past few months, experimental demonstrations of these vehicles have been given in Richmond, Norfolk, Philadelphia and Detroit. Six are now in commercial operation in New York and the operation of several is now being begun in Toronto.

A valuable contribution to the economic study of the subject of city transportation has been made by J. C. Thirlwall of the railway and traction engineering department of the General Electric Co. and a part of a contribution by him to the General Electric Review is reprinted below from The Canadian Engineer:

Many railway officials who have been searching dilligently for means to reduce operating costs and secure needed increase in revenue are demanding accurate information as to the conditions under which the ordinary trolley car, the trackless trolley bus and the gasoline bus can be used to the best advantage. The relative costs of carrying passengers in these different types of vehicles is also of considerable importance.

Comparative Advantages of the Various Types of Transit.—In this article the writer has tabulated the respective costs on a comparative basis for a variety of conditions. In general, the calculations indicate that:

(a) Where rush hour headways of 3 min. or less are required with safety cars, rail cars are the most economical and up to 6 min. headways offer successful competition to the other types where the road is a going concern.

(b) On longer headways the trolley bus appears to have the advantage due to the lower fixed charges.

(c) The gasoline bus on account of higher operating expense does not offer competition to the rail car until minimum headways of 10 min. are reached on new routes and 20 min. on existing lines.

(d) The trolley bus is more economical than the gasoline bus up to headways of 60 min. or longer.

A tabulation of the respective fields is as follows:

Minimum headways, 3 min. or less;	rail cars.
Minimum headways, 3 to 6 min.;	rail cars or trolley bus.
Minimum headways, 6 to 60 min.;	trolley bus.
Minimum headways, 60 min. or more;	gasoline bus.

Of course, as the tabulations show, the difference in favor of the trolley bus as compared to the rail car operating on headways of 7½ or 10 min. on an existing route is too small to warrant even the suggestion that rails and equipment should be scrapped and replaced with the new form of transportation. It is not until minimum headways of 15 or 20 min. are reached that the estimated saving of the trolley bus over an existing rail route becomes sufficient to justify such a suggestion.

To illustrate these conclusions and to show the premises on which they are based, a number of tables and the curves of Fig. 1 have been prepared in which a direct comparison is made of the elements of investment cost for a rail system and for the two types of busses. The actual cost of laying rail in paved streets, of erecting overhead trolley lines, or of building power stations, sub-stations or shops varies considerably as between different localities, but the unit costs used in the comparisons are believed to represent fair averages for present construction.

Construction Costs.—For instance, a figure of $60,000 per mile has been taken for single track with few turnouts laid in a paved street, $75,000 for single track with more turnouts for shorter headways, $100,000 as about the lowest estimate for a route-mile of light double track for safety cars, and $120,000 for a route-mile of heavy track for double truck cars. In some localities tracks may be laid for less than these figures; in most large cities they would be considerably exceeded; but they are believed to indicate with a fair degree of accuracy the magnitude of the biggest item of investment that can be saved by the use of the rubber tired vehicle.

Overhead trolley lines using wooden poles with cross spans can be erected for about $5,000 a mile where only one trolley wire and no feeders are required, and for double track with ordinary feeders should not exceed $6,000 per route mile. The two wire trolley required for busses costs about $500 per mile more than the ordinary type of construction and $1,000 more per mile when the line is run on both sides of the street. The transmission line is estimated at $3,500 per mile, and it is assumed that the length of the transmission system is half that of the distribution lines.

A summary of these and other unit cost figures is shown in Table I.

The rail car requires an investment

in each of the items; the trolley bus dispenses with the track, but necessitates the use of all other details; the gasoline bus requires an investment in the vehicles themselves, and in storage and shop facilities, but eliminates the remaining construction charges.

Operating Costs.—On fairly long headways, i. e., from 8 to 20 min., the fixed charges on the rail route will exceed the operating costs, and even on a heavy traffic route, they will amount to 40 per cent of the total costs of operating the line. The handicap of these heavy investment charges has given the gasoline bus its opportunity and enabled the jitneys to compete successfully in many instances with the established traction lines. The gasoline bus has a higher power bill and a higher maintenance cost than the safety car, and the depreciation of its driving equipment is decidedly more rapid than that of electric motors and control on the rail cars; but even so, for many conditions of traffic it is the more economical of the two methods of transportation. However, its proponents have frequently tried to force it into classes of service where its higher operating costs far outweigh its saving in fixed charges. Under such conditions it can only continue to operate by evading the responsibilities of good service and not attempt to provide the necessary extra equipment for properly handling the traffic peaks morning and night for which every traction company is expected to equip itself.

Table II is a comparison of operating costs per car mile for four classes of cars. The rail car data are the average of the actual records of a number of companies using both safety cars and double truck cars; the gasoline bus costs are derived from the records of five representative bus companies. Three of these use small cars seating less than 23 passengers; for these the gasoline and oil costs have been adjusted to a weight of 10,000 lb.; and for two companies corrections have been made on the basis of using solid instead of penumatic tires.

The costs of the trolley bus are assumed to be the same as the safety car and the gasoline bus as regards tranportation charges and general expenses; its maintenance of way and structure covers repairs and renewals on the overhead trolley lines only; its maintenance of equipment is based on the body and chassis and tire expense of the gasoline car, and motor and control maintenance of the safety car. For instance, safety cars on an average cost only 1.7 ct. per car mile to maintain, of which only about 0.6 ct. are for repairs to the electrical equipment. The gasoline busses cost on an average of 8.5 ct., of which 2.0 ct. goes for the maintenance of solid tires, 1.5 ct. for the body and truck, and 5 ct. for the engine and transmission.

TABLE I—AVERAGE CONSTRUCTION COSTS.

Single track per route-mile	$ 60,000 to	$ 75,000
Double track per route-mile	100,000 to	120,000
Trolley line per route mile	5,000 to	6,500
Transmission line per route-mile	1,800	
Generating station per maximum kw. output	125	
Substation per maximum kw. output	40	50
Shops per car used	1,500 to	2,500
Double-truck cars	12,000	
Safety cars	6,300	
Trolley busses	8,000	
Gasoline busses	8,000	

The trolley bus would presumably have the same cost for tires, body, and truck upkeep, but only 0.5 ct. for the motors and control, making its total maintenance 4 ct. per mile or 4.5 ct. less than the gasoline vehicle.

On the power account, due to higher friction, the trolley bus will take more power per ton mile than the rail car, but its lighter weight will somewhat more than offset this and make its total power cost a trifle less than that of a safety car. A gasoline bus weighing 10,000 lb. in frequent stop service can make only about 4 miles to a gallon of gasoline, or 5.5 ct. per mile, and oil and grease add about 1.5 ct. additional; it has therefore a total power expense of 7 ct. per mile or 4.7 ct. more than the trolley bus.

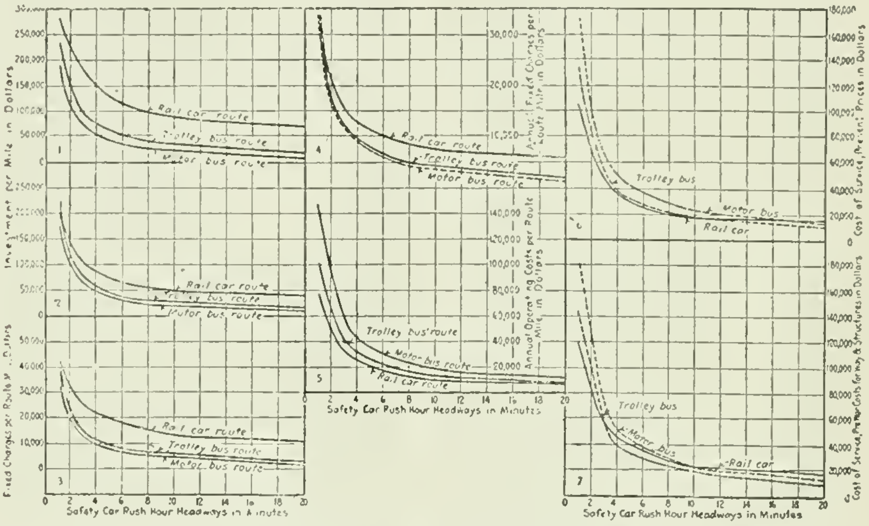


Fig. 1—Graphical Cost Analysis of Rail Car, Trolley Bus and Gasoline Bus.

Curves 1—Present day investment per mile of route for rail service compared to investment for bus service of equal capacity.
Curves 2—Investment per mile of route for rail service on pre-war costs for track and structures and present costs for rolling stock compared to the investment per mile route for bus service of equal capacity.
Curves 3—Annual fixed charges per route-mile based on present construction costs.
Curves 4—Annual fixed charges per route-mile based on pre-war costs for track and structures and present costs for rolling stock.
Curves 5—Annual operating costs per route-mile for rush-hour rail service. Headways compared to bust service of equal capacity. Longer headways during normal hours.
Curves 6—Total annual operating costs and fixed charges per mile of route based on pre-war costs for way and structures and present costs for rolling stock.
Curves 7—Total annual operating costs and fixed charges per mile of route based on present construction costs.

Fixed Charges.—The depreciation of a gasoline bus is recognized to be much more rapid than that of a rail car; apparently this is due to the comparatively short life of its engine and transmission. The economic life of a rail car and its equipment is at least 15 years. There is no reason to doubt that the body and truck of any well built bus should last that long. But from all records available, the gas engine and transmission have a life of not over 4 to 5 years, and since their first cost is about 25 per cent of the equipped bus, the total depreciation is considerably higher than for the electric car. The author has taken them respectively at 4.6 per cent for the rail car and the trolley bus, and at 8 per cent for the gasoline bus.

As shown in Table III, the total fixed charges on rail system are assumed to 15 per cent ; 9 per cent for interest, 2.8 per cent for taxes and insurance, and 3.2 per cent for depreciation on the entire physical property. Since the cost of cars, with their comparatively short life, is a bigger proportion of the total investment in a trolley bus installation, depreciation is figured at 3.7 per cent and the total fixed charges at 15.5 per cent. For the gasoline bus installation, for the foregoing reasons, total depreciation is figured at 6.9 per cent and total fixed charges at 18.7 per cent.

Costs Per Route Mile.—In Table IV there is presented considerably abridged from the original paper, a comparison of the costs per route mile for providing equivalent passenger capacity with safety car, trolley bus and gasoline bus, based on entirely new construction at present prices. Where the transportation company can use track, overhead stations and shops constructed at prewar values, assumed to be 50 per cent lower than at present, the costs are shown to be for safety car from 24 to 11 per cent less for traffic varying from light to very heavy; for trolley bus from 8 to 4½ per cent lower for corresponding traffic; while for gasoline bus the costs are reduced only about 1½ per cent for all classes of traffic.

Table IV is based on the assumption that a greater number of busses than rail cars would be required for

TABLE II—OPERATING COSTS IN CENTS PER CAR MILE.

	52-Pass. rail car, 36,000 lb.	32-Pass. safety car, 16,000 lb.	30-Pass. trolley bus, 10,000 lb.	30-Pass. gasoline bus, 10,000 lb.
Maintenance of way and structure	3.0	2.0	0.7	0.0
Maintenance of equipment	3.4	1.7	4.0	8.5
Power	5.9	2.5	2.3	7.0
All other expenses	19.0	12.0	12.0	12.0
Total operating expenses	31.3	18.2	19.0	27.5

rush hour service. A modern double truck rail car is assumed to carry 120 passengers without undue crowding, a safety car 65, and a 30-passenger bus not over 45; if the busses are to be kept within the weight and price limits specified. A comparison based on a car-for-car replacement is obviously unfair except where the maximum number of people to be carried is within the seating capacity of either type of vehicle.

Comparisons were worked out by Mr. Thirlwall based on differing density of traffic from very light to extremely heavy, and based on a completely equipped line 4 to 5 miles long, and all costs reduced to the unit basis of one route mile. Only certain characteristic traffic conditions are comprehended in Table IV and the cost of traffic with double truck cars is not there shown, although the author includes it in one of his tables. The study indicates, according to the author, that the railway is still the most economical means of handling very dense traffic, and that for very short headways there is little to choose in first cost or operating charges between a comparatively small number of large capacity double truck rail cars of modern design and the larger number of safety cars required. To handle such traffic as this, headways with the comparatively small capacity busses become so short as to be prohibitive, and their higher operating costs far overbalance their saving in fixed cahrges.

Conditions Under Which Trolley Bus Is Economical.—But for many other conditions, particularly those which are typical of the majority of lines in medium size cities, where the maximum traffic does not require headways of less than 5 or 6 min., the trolley bus should save enough in overhead charges to justify its use in preference to either the rail car or the gasoline bus.

Of the total investment required for a new rail line, under certain common conditions cited by the writer, 60 per cent is saved by using the trolley bus and 75 per cent by equipping with gas busses, and the saving is very material even against the company using old rails and structures. The fixed charges are therefore distinctly lower for bus systems, but the gasoline busses cost so much more to operate that the total annual cost of the line using them is practically the same as for the new railroad, and 30 per cent higher than for the existing rail system.

TABLE III—FIXED CHARGES ON TOTAL INVESTMENT.

	Rail system. Per cent.	Trolley bus. Per cent.	Gasoline bus. Per cent.
Interest charges	9.0	9.0	9.0
Taxes and insurance	2.8	2.8	2.8
Depreciation	.2	3.7	6.9
Total	15.0	15.5	18.7

The operating cost of the trolley bus, however, is so little more than that of the rail car that it does not offset the savings in the fixed charges, and its total cost of service is the lowest of the three sytems.

Another common traffic condition considered is for a route that would be satisfactorily handled with safety cars on 10-min. normal and 7.5 min. rush hour headways and where busses would have to run on a 5-min spacing to give equivalent rush hour capacity. Here again the use of the trolley bus is the cheapest way to equip a new line to extend an old one; the gasoline bus the most expensive means.

As the traffic grows more heavy, the advantage of the trolley bus over the rail car diminishes, but its advantages over the gasoline bus continues in the same proportion as before. The figures indicate that to re-equip an existing line would show a total loss rather than gain by abandoning rail operation.

With short headways rail operation is practically as cheap as trolley bus service, even in the case of new construction; on the old rail, operation is decidedly more economical.

A very heavy traffic route, which could use large modern double truck cars on 4-min. and 2-min. headways, is considered. It might be practicable to use safety cars on such a route, though the rush hour headways would be rather short, but no real advantage would be gained their total cost of service being practically equal to that of the large cars.

The enormous number of busses that would be required for this kind of traffic, necessitating headways of 45 sec., throws them out of the competition. Their use would not only tremendously increase street congestion, but would very considerably increase the cost of service.

The only place where the gasoline bus can successfully compete with the rail system is where traffic is so light that bus headways of 20 min. or longer afford sufficient service. In special tabulations on 20 and 30-min. all day trolley and gasoline busses headways are compared by the writer with a safety car installation operating at the same speed and frequency. With 20-min service the old rail route about balances in total cost with the gasoline bus line; at today's construction expense, the gasoline bus is distinctly cheaper. At 30-min., the advantage is decidedly in favor of the gasoline car. But at either headway, the trolley bus will have the lowest total cost of the three, and calculations indicate that its advantage over the gasoline vehicle holds up to headways of one hour or longer.

TABLE IV—COSTS PER ROUTE-MILE FOR PROVIDING EQUIVALENT PASSENGER CAPACITY WITH SAFETY CAR, TROLLEY BUS AND GASOLINE BUS—NEW CONSTRUCTION AT PRESENT PRICES.

	Safety car.	Trolley bus.	Gasoline bus.
Light traffic—			
Investment per route-mile	$ 84,800	$ 33,500	$ 20,900
Fixed charges	12,700	5,200	3,900
Operating costs	10,600	13,000	18,800
Costs per car-mile, cents	40.0	26.7	33.3
Medium traffic—			
Investment per route-mile	105,400	43,600	28,500
Fixed charges	15,800	6,800	5,300
Operating costs	15,400	18,500	26,800
Costs per car-mile, cents	36.7	25.8	32.8
Heavy traffic—			
Investment per route-mile	166,700	93,800	66,500
Fixed charges	25,000	14,500	12,400
Operating costs	33,000	42,100	60,800
Cost per car-mile, cents	31.8	25.5	33.1
Very heavy traffic—			
Investment per route-mile	284,800	259,600	192,000
Fixed charges	42,700	40,200	35,900
Operating costs	77,000	100,800	146,000
Costs per car-mile, cents	28.2	26.6	34.2

In conclusion, the writer expresses the belief that there is still a broad field of transportation on city streets for which the rail car is best suited and in which it is the most economical means of carrying passengers, but there is still another, and perhaps equally important field in which the trolley bus can furnish equivalent service at a lower cost than can the rail system. Even in comparison with the rail system, the field for the gasoline bus is very limited, (on headways of 20 min. or longer) while as compared with the trolley bus it has no place in a city transportation system, except where it is impossible to erect an overhead trolley line.

The trolley bus, however, furnishes an important contribution to the art of transportation, because its possibilities enable transportation companies to extend their lines into the suburbs or into newer sections of a city, with an investment of 60 to 80 per cent less than is required for a track system and to be able to operate cars over the new route for two-thirds of the cost of gasoline busses. With these trackless electric vehicles, it should be possible very considerably to extend the services of the city transportation companies and to benefit simultaneously the traveling public and the electric railway security holder.

How to Avoid or Overcome Rail Corrugation

Some interesting information regarding corrugated rail was given by Charles H. Clark, Engineer Maintenance of Way, Cleveland (O.), Ry. Co., in a recent issue of Electric Traction, from which we quote the following:

Some engineers hold that rigid track causes corrugations, and yet some of the worst examples of these convolutions of the surface of street car rails the writer ever observed were on dirt foundation and wood tie tracks. Very badly corrugated tracks have also been examined where the foundation was solid concrete. For this reason, the writer was led to believe that the theory was wrong.

On the principle that a heavy weight bearing on a sharp or pointed edge would be curled more easily than if distributed over a wide surface, the idea of tilting the rails to overcome this effect suggested itself. Rails have been tilted for years so that the idea of giving the head of the rail a slight slant is not new. But a little experimenting with a piece of rubber will show one that the material will flow up in waves ahead of a moving pressure. The same thing obtains with steel, but the steel when it is pushed ahead will not flow back but heap itself up in waves. Now to avoid this, the pressure per lineal inch of contact between the rail and the wheels must be reduced to a minimum, and the only way to do it is to make the head of the rail conform as nearly as possible to the tread of the wheels. The curved head rail was designed to meet this but not all companies buy that type of rail. It is easily accomplished by tilting the rail either by tilted tie plates or making your steel ties to correspond to a given angle in the rail. The Cleveland Rys., among a great many others, has been tilting its rails for about 10 years, and on any track so constructed, no appreciable corrugations have developed. Corrugations can only be removed by grinding or rubbing with emery blocks. The wheels or blocks must be tilted to the plane of the head of the worn rail, or the corrugations will begin to develop immediately.

Section Gangs Versus Extra Gangs

Committee Report Presented Nov. 21 at 40th Annual Convention of the Roadmasters and Maintenance of Way Association

In the maintenance of railroad tracks, roadbed and right-of-way, exclusive of the bridges and buildings, there are two entirely different systems for the organization of forces for the conduct of the work. One method is to maintain small regularly assigned section forces of only sufficient size to do the light work necessary to keep the tracks in proper and safe running condition. This work includes track watching and inspection, bolt tightening, ordinary gage, surface, cross level and track alinement maintenance, switch inspection and adjustment, etc. All replacement and betterment work such as tie, ballast and rail renewals is taken care of by larger floating forces or extra gangs, housed in movable camp cars so that they may be kept in close proximity to their work.

The other maintenance system is to take care of all work with the regularly assigned section forces and seldom if ever employ the larger extra or floating gangs. This necessitates much larger section forces than the first method, but has the advantage of making each supervisory foreman responsible for the continued maintenance of all work done on his section, which it is thought results in better work, more carefully done. Between these two extremes lie all track maintenance organizations.

Compromise Between Two Systems Recommended.—The purpose of this report is to suggest and recommend a compromise between the two systems best and most economically suited to the track maintenance conditions of the average American railroad. We think that all regular routine track maintenance work such as detailed gage, line, surface and cross level maintenance, ordinary track drainage, and tie renewals should be taken care of by regularly assigned section forces. They should be equipped with modern tools, in good condition and in sufficient quantity, and have suitable motor cars. This permits the economical assignment of longer sections of track than is practicable with the old-fashioned lever or hand cars, and conserves the time and physical strength of the men for useful work. The forces should be maintained at as nearly as possible uniform strength throughout the year, with slight seasonal additions during the heavy working season from April to November in the average American climate. This makes possible and encourages the employment of a better and more skilled class of labor than the great seasonal force variations sometimes practiced, where a bare skeleton organization is maintained through the winter, and a large number of extra, and usually floating and poor quality laborers are added during the summer. Nothing is more important in track work than satisfied, experienced and regular workmen.

The heavy track replacement work such as continuous rail renewals, and heavy ballasting out of face should be taken care of by specially organized forces, housed in movable camp outfits. Extensive fence building or rebuilding and cut or bank widening can also best be taken care of by special forces. Such special forces become skilled in their work and reduce unit costs to a minimum. They should be required to leave their work in a completed condition, and not leave parts of it to be completed by section forces.

Handling Special Lighter Work.—Between these classes of usual routine maintenance work and special heavy maintenance work, which should be taken care of by regular section forces and special extra gang forces, respectively, there are some kinds of special work of a lighter nature which can be handled economically by increasing the size of and, if necessary, doubling up the regular section forces. Such work includes scattered rail patching, curve worn rail renewals in short patches, and ballast cleaning and patching or light resurfacing in short stretches. No heavy ditching should be done by hand, as one of the several good mechanical ditchers on the market, handled by a work train and attended by regular section forces, with a few extra men, will take care of almost any ditching condition economically.

Working Section and Extra Gangs Together.—Frequently section and extra gang forces can be worked together advantageously where a large number of men are needed for a short period, but cannot be worked continuously to advantage. On one road extra and section forces are combined for rail renewals. The regular rail extra gang makes necessary preliminary preparations for renewing a stretch of rail, then the track is taken for a day and the rail gang, with the assistance of section forces brought in from 15 miles in either direction, will relay from two to three miles of rail in 10 hours, while the trains are being handled over another track. A large number of skilled track men can thus be gotten together for a short period, and it is found that the men, working harmoniously under the roadmaster and his assistant, will do the work much more cheaply than it can be done by large extra forces working under traffic, and with much less resultant delay to heavy freight traffic. After the rail is laid, the extra gang completes the work of cutting the old rail apart, loading it up, renewing ties and switch timbers under new rail as may be necessary, and other work incident to completing the job.

The same practice of doubling section forces for a short period may be followed advantageously in making short patches of curve rail renewals, or surfacing short stretches of track out of face where the work is too heavy to be handled by one average section force, but not great enough in extent to justify the moving in of an extra gang.

Often local conditions largely affect the working program. Where there is a good supply of local labor in a section where heavy track work is to be done, it can frequently be done advantageously by the local section foreman with an increased force, but under such conditions he should be given an assistant to look after the routine details of his section so he will not have to divide his attention between the heavy work and the regular routine work.

Ordinarily maintenance should be kept up currently so that the necessity of organizing large extra forces for heavy seasonal work may be reduced by a minimum. This can be done where reasonable section forces are maintained throughout the year. Routine fence repair work, for instance, can best be done by regular section forces in the late fall and winter when the undergrowth is down, eliminating the necessity for special fence repair forces in the summer. The same is true of rail patching, drainage improvement, pipe replacements, etc.

In short, track work should be so handled as to reduce to a minimum the growth of conditions requiring unusual and heavy seasonable repair work, but when such conditions do exist from betterment necessities or unpreventable causes, the heavy work should be done by special extra forces and not by doubling large section forces for any length of time, and taking men away for long periods from the maintenance of the special territories to which they are assigned.

Committee: R. H. Smith, chairman, assistant division superintendent, N. & W. R. R., Roanoke, Va.; I. D. Talmadge, roadmaster, N. Y. O. & W. Ry., Middleton, N. Y.; George Kohn, roadmaster, C. R. I. & P. Ry., Joliet, Ill., and J. A. Roland, roadmaster, C. & N. W. Ry., Missouri Valley, Ia.

American Engineers Plan Reception for Italian Ambassador.—American engineers are planning a big reception to Prince Gelasio Gaetani, Italian ambassador to Washington, now on his way to this country. A dinner, at which engineers from all parts of the country will be present, will be given in honor of the new diplomat, himself an engineer, by the American Engineering Council of the Federated American Engineering Societies in Washington on the evening of Jan. 12. The dinner will be the concluding event of the two-day annual meeting of the Council, which will consider problems of national interest, including the report of the Committee on Work Periods in Continuous Industries, which has reported in favor of the eight-hour day. Dean Mortimer E. Cooley of the University of Michigan, president of the Federation, will preside.

Civil Service Examination for Valuation Engineers.—The U. S. Civil Service Commission has announced the following open competitive examination: Valuation engineer, $3,600-$4,800 a year; associate valuation engineer, $3,000-$3,600 a year. Oil and gas; coal mining. Applications will be rated as received until March 1, 1923. The examinations are to fill vacancies in the technical staff of the Income Tax Unit of the Bureau of Internal Revenue.

Lost Efficiency of Maintenance of Way Men

Address Nov. 21 at 40th Annual Convention of Roadmasters and Maintenance of Way Association

By C. A. PAQUETTE,
Chief Engineer, Cleveland, Cincinnati, Chicago & St. Louis Ry.

To me, the maintenance of the track is the most interesting part of rail road maintenance; not because of its construction, which is simple, not particularly because of its use, but because of the human element involved. The maintenance of equipment is performed at certain concentrated points. We have shops for the maintenance of locomotives, shops for the maintenance of cars, and the forces so engaged can have intensive supervision, but in the maintenance of way it is wholly different. We maintain, on every foot of the railway, from one end of the line to the other. Our maintenance supervision must be more or less general in character, and when the emergency arises, your roadmaster isn't there and our engineer isn't there, so it devolves on the track foreman; and it is on his energy and on his foresight and on his resourcefulness that we must depend for the safety of trains. This is the particular feature in maintenance to which I wish to direct my remarks.

The president of the New York Central R. R., in a public statement, made some time ago, said that 95 per cent of railroading was the human element. In other words, the efficiency of the railroad depends upon the organization and on the co-operation of each member of that organized unit. In our particular department, the cost of labor exceeds the cost of rails, ties, ballast, fastenings, bridges and everything else rolled together.

The big question, therefore, is how to get efficiency out of the applied human effort. I have known a great many track foremen; I have walked along the track; I have ridden motor cars and hand cars; I have stopped to talk to these men—fine, earnest, painstaking, loyal—always speaking to me of the line as "our railroad" and not as "the railroad."

Changed Attitude of Men.—They took a pride in their work and a genuine satisfaction in their accomplishment. The regretful thing is that this, to a large extent, has passed, and there has been a most changed attitude on the part of these men in the past three years. From the spirit manifested in some directions it would seem that these men are trying to evade the curse that Almighty God laid on the head of man when He drove him from the Garden of Eden —"By the sweat of thy brow shalt thou eat thy daily bread." This change of front of our people could not have come except through outside propaganda, fostered by interests that thrive on discord and distrust.

Oh, that there could be emblazoned on the walls of those lodges, "Render unto Caesar the things that are Caesar's," and that they would take that to heart! The obligation to give an honest day's work seems to have gone out of fashion.

We have, for the past 15 years or so, seen attempts on the part of professional organizers to get all classes of railway employes associated into unions covering the various lines of activity. Hard on the heels of government control came politicians, seeing the opportunity for the creation of a political machine, fostered organizations of these men, under the guise of convenience in having the men represented by the heads of outside organizations in negotiations covering their wages and working conditions. Organizers, watchful of their self interests, saw the golden opportunity and were quick to take advantage of it.

The Old Time Loyalty a Thing of the Past.—A short time ago, a railroad executive was talking to me and he was deploring the situation as it exists today. He said, "That old-time loyalty of a railway employe seems to be a thing of the past." I told him that he was to blame—he and the rest of the railroad officials.

What have we done to overcome this? We have seen attempts to inoculate these men with the virus of discontent and suspicion, and what have we done? The small units of railroads of the past have been swallowed up in the larger organizations, and the day when the president and the general manager knew "Bill," the engineer, and "Jerry," the section boss, seems to have passed away. Nowadays the superintendent is too busy looking over his reports and dictating his mail to know the trainmen, much less the trackmen. The engineer who knows all his section foremen is the exception rather than the rule.

The Personal Element Lost.—I read an article in a magazine a short time ago that purported to have been written by the maker of a very popular and commonly-seen automobile. It was somewhat of a shock to me to read his remarks to this effect: In his factory they did not believe in the personal element; that big business was too big to take into account the human element. I cannot believe that railroading can be carried on with such a doctrine. In too many phases of the operation of the railroad, must the matter be left to the energy and to the foresight of the man on the ground, guided without any directions other than that of his own good sense and his interest in the service of the railroad. I believe most strongly in the human element— in the personal element.

Much of this we have lost. In the past two or three years, because of the new influences that have been injected between the railroad and the employe, the elements that are fostered and can thrive only through the medium of breeding discontent, of employment and suspicion of the activities of the employer.

Just a few days ago I was visited by two maintenance-of-way men, one a track foreman and one a bridge foreman. These men said to me, "Whenever we go into the meetings of our union all we hear is petty grievances, complaints fancied or real, but always exaggerated, about the attitude of the railway officers. We have yet to hear a single word for, on behalf of, or in the interest of the railroad. And we feel that we can not be loyal to the railroad and to our union, too. We want to know the way out."

Now these men were earnest, in dead earnest. They both have been in the employ of the company for some 15 to 20 years. They said that in all of their service they had never known of any reason to impugn the good faith of their officers; that they had been dealt with in such a way that they were duty bound to maintain their loyalty to their employer above all outside considerations.

This is a nation in whose veins flows the blood of pioneers. Individual energy, individual resourcefulness, individual ambition are the things that have placed us where we are. Are we going to destroy that feeling in this latter-day philosophy, by this new psychology? Are we going to measure the ambitious and the efficient by the same yardstick as we do the indolent and the worthless, whose sole concern is to do just enough to get him by and hold his job? If we do, we destroy that which has made this country great. If we do, we relegate the workers to an industrial equality that is nothing more than a colorless mediocrity; we stifle ambition, energy —the things that give mental satisfaction with material rewards to the deserving. Do we want this? Do the workers of the country want this? I don't believe it.

I had a committee wait on me some time ago and one or two of the members displayed a little more than the usual amount of truculence. Finally, I told them that we had not yet turned the railroad over to the employes; that we were not in Russia; that they hadn't Sovietized us yet and by the Eternal, unless I mistake the American people, they are not going to Sovietize us.

I have been more concerned over the situation with respect to maintenance-of-way men than over any other question concerning the railroads. We must find a way to regain their confidence, trust, their old-time interest and pride in their work. You can't make me believe that these things have disappeared—they are merely, for the time-being, submerged.

One of our statesmen said, some time ago, that what this country needed, more than anything else, was a good nickel cigar for 5 ct. There is a great deal of true philosophy in that remark. What is needed is a return to a sense of proportion and a sense of true values. What is needed is a sense of value given for value received; and, by the same token, value received for value given.

How to Regain Employes' Loyalty.—Now in the past two or three years the employes of the railroads have certainly gotten a distorted sense of values and a distorted sense of perspective. It is our duty to help them regain these. You are the connecting link between that vast army of maintenance of way workers and the railways in whose employ they are. Upon you rests the responsibility for the restoration of those relations which never should have been disturbed and which would not have been had we been one-half as energetic as these outside influences. With you rests the intimate connection, the line that closes the circuit between the road men, the employe and the railway company, in whose service they are. It doesn't detract from your dignity to meet these men and say, "Hello, Bill, how is the sore thumb?" or "Hello, Jack, is your boy still going to school?" Don't lose sight of personal touch. Manifest something of that bond of human sympathy that ought to hold us together. Give them a word of commendation for a job well done, a word of encouragement for the persevering, a word of help where bolstering is needed. You will find that this means a great deal to these men.

Your men frequently want advice. They want somebody to whom they can talk, not only about their railroad affairs but about their personal business. Be you that man. Don't let it be confined to lodge officers. Under a situation such as now exists, you are derelict in your duty if you stand on the side lines and look on. Don't widen the gap. Close it! Stand up in your shoe leather and meet trouble-making demagogues and discontent-breeding organizers with as much energy as they display. Regain the old footing and the old feeling of personal interest and attachment which was once the marked characteristic of the men. There, and there only, is the way to efficiency.

Factors in Design of Street Railway Track

Abstract of a Paper Presented at a Conference of City and Railway Engineers Held Oct. 9 at the Engineers' Club, Philadelphia

By W. W. WYSOR.

Chief Engineer, United Railways & Electric Co., Baltimore.

In designing street railway tracks, there are so many factors to be considered that it is impossible to provide specifications that would govern in all conditions. Any specifications that are prepared, therefore, and which are meant to apply to the entire track structure, should be only very general in character.

Conditions to Be Considered in Selecting Type of Track.—Once the particular type of construction is decided upon, more detailed specifications may be prepared; but, even then, local conditions must be considered if we are to attain the best results from a structural as well as financial point of view. Some of the conditions that must be taken into account in the decision as to the type of track to build are:

Type, weight, etc., of equipment that will operate over the track.

The kind and volume of vehicular traffic, other than street cars.

Nature of underlying soil.

Other structures in the street.

Climatic conditions.

Width of streets and character of paving used.

Character of community served.

Lastly, but by no means least, the financial condition of the concern responsible for the railway.

Manifestly, the light, cheap construction, often found in small towns, would not be suitable for a busy metropolitan district, nor would the heavy, expensive track employed in the congested parts of big cities be justified in the country village.

The Ideal Type of Track.—From a strictly railway point of view, the ideal type of track would be a tee-rail on private right-of-way, but that is obviously impossible. In downtown areas, the necessity of having the entire street available for vehicular traffic of all kinds makes it necessary to pave over the track area and hence to adopt some type of track structure suitable for such paving. In outlying districts, however, where width of streets will permit, it is desirable to maintain the track on a private way, with a driveway on each side. This private way may be inclosed by a curb, hedge, grass plot, row of trees, etc., as the width of the street, character of community and individual taste may dictate. This type of construction permits higher speed, makes for greater safety, less noisy slag or crushed stone or, in the latter case, it may be that the run of the crusher will accomplish the best results rather than the use of a uniform sized ballast. Then again, conditions may be such that drainage of some kind or another should be resorted to. The existence of storm water sewers in the streets has a very large effect on the conditions of the sub-surface soil in many cases.

Economy Important Factor in Track Design.—The last important factor is that of economy and it is in meeting this requirement that the engineer is called upon to exercise his greatest ingenuity, and is largely responsible for the many different details of track construction in use by electric railway companies in this country today.

One engineer will advocate stone ballast. According to his idea 6 in. of such ballast should be placed under each tie. Another engineer, while agreeing that stone ballast is the proper material to use, will say that 4 in. under the tie is sufficient. Still another engineer will say that just as satisfactory results are obtained by the use of gravel, crushed slag, or perhaps cinders for this purpose. Probably all three are obtaining satisfactory results, and it is here that local conditions play a very important part.

In one locality crushed stone may be scarce, it may have to be hauled a long distance, while gravel is obtainable locally at a low cost. In the other case it may be that good cinders are obtainable whereas neither stone nor gravel is to be had at a reasonable cost. Or it may be that the natural soil condition is such as to make it unnecessary to use other than the natural soil for ballast.

The Matter of Ties and Tie Plates.—In the matter of ties, some engineers specify white oak ties because they can still obtain them locally or within a reasonable distance of their property. But it would be out of the question to require every property to use white oak for this purpose, for it could not be obtained in sufficient quantities at any price. There are plenty of other woods which answer the purpose for electric railway track conditions equally as well at considerably less cost. Many otherwise inferior classes of woods are made entirely suitable for railway ties by the use of a proper preservative treatment.

Tie plates may or may not be necessary or desirable. This depends entirely on the weight to be carried by each tie, and the compressive strength of the wood at right angles to the fiber. If the rail base and the tie at the rail bearing point are wide enough to provide a bearing area sufficient to keep the unit compressive strength within the proper working limits and prevent excessive cutting during the life of the tie, then tie plates are not necessary and they only increase the cost.

The next thing of importance is the selection of the proper method of joining the rails together, for, if the life of the track as a whole depends on the rails, the life of the rail in turn depends on the joints. Street railway engineers realized many years ago that the common form of bolted joints could not be depended on to give satisfactory service in paved streets, and their attention has been turned toward some way of welding rails together, so as to, as far as possible, eliminate the joint.

Effect of Local Conditions on Track Foundations.—Having selected the rail it should be laid upon a foundation that will properly support it throughout its life. Here, again, local conditions make it impossible to lay down any specific rules to govern all cases. Attempts have been made to eliminate the ties and support the rails directly on concrete beams or slabs, but none of these has proved successful. The usual practice is to support the rails on cross ties of wood or steel, laid on ballast of some sort, or, in some cases, on the natural soil where it is of such character as to justify this procedure. The ties should be of such quality that they will not decay during the life of the rail and of sufficient size and density to prevent the rail cutting into them seriously. They may be assisted in this last respect by the use of tie plates.

The foundation under the ties should be of sufficient stability to support the track, paving, and live loads without appreciable settlement or movement of ties, and of such character that it will not in the presence of water work into muck and permit a pumping action to be started. This sub-foundation should be self-drained, with ample provision for carrying the water to city sewers or other suitable places of disposal, or else it should be so dense as to be impervious to water. Beyond this, it would seem needless to go.

While some attempts have been made to build so-called "permanent" foundations, where it would only be necessary to renew the rails from time to time, I do not believe they have been attended with much success, for streets are subject to settlement, due to construction of numerous underground structures, such as sewers, water, steam, gas pipes, conduits, etc., and as a general proposition, when the time comes to renew the tracks, they must be given a general resurfacing and realigning.

Mechanical Engineer for Government Service.—The U. S. Civil Service Commission has announced an open competitive examination for associate mechanical engineer (internal combustion engines). The examination is to fill a vacancy in the position of engineer of tests at $10.56 a day, for duty in the aeronautical engineering laboratory, Navy Yard, Washington, D. C., and other such vacancies should they occur later. The receipt of applications will close on Jan. 30. The duties of the appointee will be to act as technical advisor to the officer in charge and to take actual control of testing and designing work.

Effect of Street Railway Track in Pavements

Abstract of a Paper Presented at a Conference of City and Railway Engineers, Held Oct. 9 at the Engineers' Club of Philadelphia

By JULIUS ADLER,
Deputy Chief, Bureau of Highways, Philadelphia.

Under conditions such as exist in Philadelphia, the presence of street railway tracks almost invariably shortens the life, increases the annual maintenance cost and greatly magnifies the difficulty of keeping street pavements in safe and usable condition. The influence of the tracks in promoting pavement deterioration is first direct, as evidenced immediately along the rails, and second indirect, with the deterioration occurring both near and at a distance from the rails.

Wear Due to Flexible Type of Track Construction.—Under the heading of direct wear a considerable portion of the trouble originates with the railway engineer's insistence upon the flexible or non-rigid type of track construction, for the matter of harmonizing flexibility in track construction with reasonable permanency in the abutting pavement construction is apparently an unsolved problem. What is the definition of this term flexibility? How much must a rail be permitted to deflect in order to give reasonable length of service? How much can a pavement be expected to deflect and still maintain its integrity? Unfortunately, there seems to be no exact answer to these questions. Even the most rigid types of pavement do deflect, under heavy loads, an amount capable of measurement with suitable appartus and without apparent detriment. The less rigid types, such as those on macadam foundations, or bituminous bound foundations, together with sheet asphalt, granite block with bituminous mastic filler and brick with asphalt filler, deflect to a still greater extent under loading in the ordinary course of events.

In the highway field, as in the railway field, there is an active controversy concerning the relative merits of the flexible and non-flexible types. But as applied to pavements, there is one fairly safe rule, namely, when the deflection of the pavement under the ordinary maximum load is clearly visible to the eye, there is trouble ahead. On the same basis, when the vertical movement of railway tracks becomes apparent, there is little hope for the adjoining pavement, be it ever so flexible. Stone block, or other types of pavement laid adjacent to a rail, may be bound together with a flexible asphalt cement, but when the rail begins to work, the frequently repeated movement and the access of water to the foundation will invariably cause the breaking down of the pavement.

Arguments for and Against Non-Rigid Type.—At the city paving meeting held in Philadelphia a year ago, E. J. McIlraith of the Philadelphia Rapid Transit Co., ably presented the arguments in favor of non-rigid track construction as practiced by his company. Using a 9-in. 141-lb. girder rail laid on a 5 in. x 9 in. x 8 ft. ties, spaced 22 in. on centers, laid on the natural soil, his calculations showed a maximum pressure transmitted by the tracks to the supporting soil of approximately 0.4 ton per square foot as against safe working pressures of 4 to 6 tons per square foot as used in building foundation construction. Mr. McIlraith concludes: "Is it not then clear that a very safe margin of loading exists, and that any more expensive structure to instill, to maintain, or to remove, that would still further blanket the load over a wider area of soil, would represent a waste of money?"

From the paving engineer's standpoint, the method of reasoning and conclusion arrived at are incorrect in several respects.

In the first place the calculations are based on static loads, but the effects of impact, the most difficult of all conditions to deal with in engineering structures, are entirely disregarded. It may be said that when the track structure is properly installed there is no occasion for impact occurring on straight track, free from special work, but this assumes a degree of perfection which, experience shows, is never attained.

No ordinary methods of working can produce a subgrade under the track which is of uniform bearing power and free from soft spots, with the result that the track structure described does move perceptibly in places almost immediately after the final tamping. It is further evident that, in service, the head of the rail does eventually develop inequalities which cause impact from the moving wheels.

In the second place, the reasoning employed by Mr. McIlraith's discussion gives scant consideration to the fact that the movement of track structures and the accompanying deterioration of pavement, form a progressive action. A persistent slight movement of the rails will break the bond of the adjoining pavement at least sufficiently to allow moisture to enter slowly.

The later movement of the rail, in the presence of moisture, sets up the pumping action so often referred to in track structure, and if the material supporting the track structure is of a character which can readily be pumped (and natural soil certainly is) the support of both the track and pavement steadily decreases in this locality, the amount of movement in the track increases at a progressive rate and the breaking down of the pavement follows with increasing rapidity.

The conclusion seems to be that in order to keep paving intact around railway tracks, the amount of possible movement in the tracks must be definitely limited from the very start. This cannot be accomplished by laying the track structure directly on the ordinary clay soil and there must be a slab of concrete of proper thickness and strength placed below the bottom of the ties.

We do not claim, however, that the railway engineer's contention for flexible track structure is incorrect, providing the degree of flexibility is limited. For example, if an intermediate layer of porous material is placed between the concrete slab and the bottom of the ties, flexibility can be accomplished by this means and no harm done to the pavement provided the material so placed is of a character that is not readily pumped (when moist) by a very slight deflection of the track.

Indirect Influence of Tracks on Wear of Pavements.—This is a condition which varies with the width of the streets, number of tracks in the street, amount and weight of car traffic, and amount and weight of vehicular traffic. In Philadelphia unfortunately a very large proportion of the most important streets are too narrow to accommodate properly car traffic and vehicular traffic as they now exist. The headway between cars is so close that during the busy hours of the day vehicles have but little opportunity to use the central portion of the street and are forced to move in a narrow path, usually on one shoulder.

At the city paving meeting a year ago, the opportunity was taken to point out this fact as one of the most serious problems to be contended with in the maintenance of asphalt pavements on railway tracks streets in Philadelphia. These pavements laid on a 26-ft. cartway free from railway tracks give very satisfactory service, but laid on a street of the same width with a track in the center the concentration of traffic on a narrow shoulder often causes excessive disturbance of the pavement surface.

This fact, however, is not limited to asphalt pavements alone, for there is no known type of city pavement in general use whose life is not very much longer under well distributed traffic than under heavy traffic following a narrow path. There are examples in Philadelphia of granite block, wood block, and vitrified brick on streets occupied by railway tracks, all showing well defined ruts as a result of the traffic being forced to follow a narrow path.

This general condition, which in a city of narrow streets causes a heavy increase in pavement maintenance, costs, is one which must fairly be attributed to the influence of the railway tracks, but unlike the matter of disintegration along the rails, it is a responsibility which must be faced by the city alone.

Railway Mileage of the World

In a recent article the "Archiv fur Eisenbahnwesen," presented its annual compilation of the railway mileage of the world. An interesting analysis of this compilation is given in Railway Review.

The world's mileage in 1920 was 748.005 miles. This is distributed among the continents as follows:

	Mileage.	Per cent of total.
The Americas (North and South)	380,194	50.8
Europe	237,888	31.8
Asia	74,115	9.9
Africa	32,239	4.3
Australia	23,569	3.2
Total	748,005	100.0

North and South America combined contain over one-half of the railway mileage of the world, America and Europe combined contain over four-fifths, while the great areas of Asia, Africa and Australia combined represent the remainder of less than one-fifth.

The railway mileage of the United States of America is reported as 264,373 miles. This is approximately 70 per cent of the total mileage of the Americas and 35 per cent of the mileage of the world. It exceeds the total mileage of Asia, Africa and Australia combined by more than 100 per cent.

Methods of Making Tie Renewals

Committee Report Presented Nov. 21 at 40th Annual Convention of the Roadmasters and Maintenance of Way Association

1. **Should Tie Renewals Commence at Some Fixed or Stated Period During This Year? If So, When?**—Tie renewals should commence as early in the spring as possible. The exact time depends solely on climatic conditions. This gives the track foreman four months in which to get all of his ties in before hot weather, for in the opinion of many trackmen, if ties are put in in hot weather the chances for buckled track are increased. The hot months can then be used for weeding, ditching, dressing ballast and other work. If any ties remain to be renewed this work can be completed in the autumn months. This holds good for any kind of ballast.

2. **What Is the Best Method of Distributing Ties for Renewals and When Should This Be Done?**—The most economical method of distribution is by the work train in the late fall or winter months. Exceptions to this, however, occur when the ties are not received in sufficient quantities to warrant the use of a work train; also if the country to which the ties are to be distributed is subject to spring floods, it would not be advisable to distribute them until near the time for renewal. Ties unloaded from a work train should be piled in neat piles so as to prevent rot, permit seasoning and improve appearances along the right of way. Flat places should be selected in order to insure against their rolling down embankments, and require additional handling. Some object to distributing ties during the winter because they do not have sufficiently large gangs to handle them properly at this time of the year. A good answer for this objection is to consolidate gangs over a district while distributing the ties within the district.

3. **Should Ties Be Spotted in, Starting at One End of the Section and Replacing the Bad Ties to the Other End?**—There is a difference of opinion on this question. Ties spotted in stone or slag ballast over a whole section have been found to cost an average of 60 ct. each where a regular section or extra gang is used. On many roads the spotting in method is not regarded with favor, where the drainage is not good, as it often causes sloppy track and broken rails, and it is used by them only around a curve or a joint where the ends of the ties are found broken.

Where the drainage is good, ties spotted in do not disturb the track, but at best the cost per tie is more than with other methods. Ties can be spotted in gravel or cinder ballast to good advantage. It has been found that it costs an average of 30 ct. per tie to spot them in gravel or cinders. Where the track is full ballasted or light ballasted the cost averages 20 ct. per tie.

4. **When Ties Are Put In, Should the Track Be Given a General Lift?**—Renewal by this method costs from 20 to 25 ct. per tie in stone ballast, while in gravel the average cost is 12½ ct. Giving the track a general lift in most instances provides a better bearing for the ties and insures better riding track, affords a better opportunity for renewing anti-creepers and tie plates and provides an accurate spacing of ties. As a general practice it is a much more satisfactory method than spotting in.

5. **Should Ties Be Put in One or Two Miles of Track on a Section Each Year and the Balance of the Section Let Go as to Ties and General Lift?**—In general, in stone ballasted track of dense traffic, from the information obtained, the most satisfactory results are secured by giving the track a general lift over two to three miles of a section each year, putting in ties and working the track thoroughly. The balance of the track is left alone as far as ties and a general lift are concerned, except for some smoothing and lining. This method establishes a cycle of three or four years and necessitates work of a character to last for three or four years.

6. **Should Ties Be Taken Out That Will Last Approximately a Year Longer?**—Many railroads prefer to leave a tie that will last a year longer if this can be permitted. However, if the practice of working a third or a quarter of a section each year is followed out, it is necessary to remove the tie and, if its condition warrants, use it in a spur track or siding, since it would be necessary for the ties left in the track to last 3 or 4 more years.

7. **Where Do You Find It Necessary to Renew Ties Out of Face?**—This occurs most frequently through private or highway road crossings where travel is heavy and where the ties are covered in any manner. The only feasible way of renewing ties under such conditions is out of face. The cost of tearing up a crossing or a platform in two or three years will be justified by the additional service obtained from the ties. Fairly good ties removed in this manner can be used to good advantage in spur tracks, yards and sidings.

8. **In spotting in Ties, Should the New Ties Be Put In a Spike High or Tamped Solid?**—Ties put in a spike high are not favored by the majority, although many agree that a tie should be put in a trifle high, but not as much as the thickness of a spike. The largest number favor tamping solid. Ties put in stone ballast give best results when tamped solid, while ties put in a spike high are not warranted or practical. The idea of putting in ties a spike high meets with greater favor in gravel or cinder ballast than in stone ballast and under many conditions proves satisfactory, although other conditions will warrant the tamping of all ties solid.

9. **In Spotting Ties, Should the Track Be Given a General Surface or Should the Low Places Be Given Attention at This Time?**—If the spotting-in method is used it is hardly advisable to give the track a general surface unless it is in a serous condition. If the track is to be surfaced in connection with the putting in of ties, some other method than spotting in would be more practical.

10. **After a Roadmaster Sends in His Estimate of Ties Required for Curves and Tangents for the Succeeding Year, Should He Be Advised Whether He Will Be Furnished the Number of Ties to Meet His Requirements Before Deliveries Are Commenced?**—For economical tie renewals, it is essential that the roadmaster or supervisor be notified of the number of ties he will be furnished. If this is not done, he cannot distribute them economically, for he is required to unload ties first at his worst places, and they cannot be handled as quickly or as economically as if he knows how many ties he is to receive and can make out a distribution schedule whereby he can distribute the ties with a work train with the same operation, whether he has received his full quota or not. If the roadmaster does not receive his full quota of ties, it affects his method of renewal to a great extent, for if such a condition exists ties that will last a year or two longer may of necessity be left in the track. The failure to furnish the roadmaster's requirements may result in a temporary saving of expenditures, but it is uneconomical at best, considering the cost of the additional labor required to maintain the track under such circumstances.

Conclusions.—It is the opinion of the committee that no one method of tie renewals can be prescribed, for a method that fits one road may not fit another. The method depends on the number of tracks, kind of ballast, price of ties, price of labor, financial condition of the railroad, roadbed and drainage conditions, condition of the track, and the topographic and climatic conditions of the country through which the railroad runs. The above is the consensus of opinion obtained from the answer of 26 roadmasters and supervisors over the country to a questionnaire submitted by the committee.

Committee: J. P. Davis (chairman), roadmaster, Central Indiana, Anderson, Ind.; A. M. Clough, supervisor, N. Y. C., Batavia, N. Y.; C. H. Royer, supervisor, B. & O., Newark, Ohio; C. E. Miller, supervisor, Penna., Titusville, Pa.; W. H. Sparks, general inspector of track, C. & O., Russell, Ky.; W. H. Saltsman, supervisor, Penna., Ravena, Ohio.

New Officers Elected At 34th Annual Meeting of State Railway Commissioners

The National Association of Railway and Utilities Commissioners met at Detroit, Mich., on November 14 to 17, inclusive, in its annual convention. Attendance was the largest in the history of the organization, more than 100 commissioners being registered.

The following officers were elected for the ensuing year: President, Dwight N. Lewis of the Iowa Commission; first vice president, Alexander Forward of Virginia; second vice president, H. G. Taylor of Nebraska; secretary, James B. Walker of New York; assistant secretary, J. H. Corbitt of Tennessee, and general solicitor, J. E. Benton, Washington, D. C.

Tests for Gases in Street Manholes.—Ten manholes of the local telephone company suspected of being gaseous were recently inspected by chemists of the U. S. Bureau of Mines Experiment Station at Pittsburgh, Pa., and samples of the atmosphere taken for analysis. Tests were made with the I.O. gas detector. The hose mask was tried and worked well in all situations. When the anlyses are completed, it is proposed to visit selected holes and test with the Burrell gas detector, safety lamp, rubber balloon and cylinder and spark plug (a new instrument that has been devised).

Labor Saving Equipment in Maintenance of Way Work

Committee Report Presented Nov. 22 at 40th Annual Convention of the Roadmasters and Maintenance of Way Association

The shortage of labor in railroad work during the last few years had led the railroads to substitute mechanical devices for labor in an effort not only to reduce the cost of the work, but also to get a larger percentage of it done during the season. Little money is saved by the use of some mechanical devices, but the fact that less labor is needed (at times of shortage) makes the use of these devices worth while, as it enables the roads to get work done which would be impossible otherwise.

When machinery is used it must be utilized in an efficient manner and the organization should be instructed thoroughly as to the part each man or small group of men is to perform in order that the work may progress efficiently. All concerned, division engineers, roadmasters, foremen and laborers, should co-operate in giving the device close study and understanding its possibilities. Even after a labor-saving device has been established in service, after having gone through severe tests and the equipment is considered standard, it does not necessarily mean that success will always continue to any marked degree unless the machine is handled properly, kept in regular repair and operated correctly.

Rail-Laying Machines.— Labor-saving devices are being utilized more and more to speed up the renewing of rail and a great deal is saved by their use. Where long stretches of rail are to be renewed, locomotive cranes are coming into use to replace the tong gangs. On account of the increasing weight of the rail its handling by hand is a costly operation and where a derrick can be procured that will move under its own power a great deal can be saved. If there are men enough available, it is advisable to use two cranes, one to lay the line side and the other to follow laying the gage side. The cranes can be followed up by pneumatic bolt tighteners, pneumatic air drills and pneumatic machines to take off old bolts, the pneumatic tools securing their air from signal pipe lines, if they are available and have sufficient excess pressure, or where they are not used, from a tamping machine compressor.

In laying rail with equipment of this kind it is necessary to arrange for the exclusive use of the track until the work is completed and for the mechanical equipment to be brought to the nearest siding or yard prior to the beginning of the work.

In order to operate these machines economically there should be men enough to keep the work going as fast as the machines will operate. The force to lay the rail on one side should include at least 125 men with 1 locomotive crane, 6 pneumatic bolt runners, 4 pneumatic air drills and 2 rail-loading machines, the latter in a work train picking up the old rail, angle bars, scrap, etc. By using section gangs better supervision of each unit of work is secured, as each group of men will work under its own foreman.

Cost of Renewing Rail.—The cost of renewing rail by the use of machines, based on using 2 cranes, 4 portable air compressors running 8 pneumatic machines, a work train with 4 double end rail-loaders and 262 laborers and 26 foremen or assistant foremen was as follows:

	Per ton.	Per mile.
Unloading 3,161.5 tons of new 107-lb. rail	$0.49	$ 82.39
Distributing angle bars, tie-plates, spike and other accessories	.34	57.17
Scoring ties and other preliminary work	.22	36.99
Taking out old 100-lb. rail and renewing with new 107-lb. rail, including picking up old rail and scrap	3.29	533.18
	$4.34	$729.73

The above included the cost of installing new tie-plates and rail anti-creepers, but did not include the renewing of turnouts which were jumped and renewed later with a smaller gang. This work, as done in the past by hand and including the cost of closing in for trains, would aggregate approximately $12 per ton or $2,000 per mile.

The committee feels that on account of the lack of labor and the increased rates now paid for it the roads should give over the entire use of a track on railroads with two or more tracks when renewing rail, for if the track is not given up the machines will not save any money, but will increase the cost because of the delays in getting the equipment into the clear of trains.

Where only a few men are available the three-man track layer is a valuable asset, especially in laying rail in yards. While the machine is called a three-man track layer we find that the work is done more economically with five or six men and a saving of approximately $300 per year for each machine in use can be made, based on the fact that these machines with 5 men will do the work of 15 men and assuming that they are used about 2 hours per day, for 60 days in the year. This saving can, of course, be exceeded by the more frequent use of the machine.

Rail Unloaders.—At the present time we are unable to handle rail in any quantity by hand and it is necessary to use bridge and building derricks on some roads in order to make any headway. These derricks are not designed for quick operation and require an engineer and fireman to operate them, whereas rail unloaders are especially designed for this work and can be operated quickly by the foreman or an experienced laborer.

With the increased weights of rails, frogs and switches, the necessity for these machines becomes more pronounced. The saving in time in handling and reshipping rail will enable more work to be done in a season The machines are operated by compressed air taken from the train line and, like other labor-saving devices, can be put to other uses, such as handling heavy signal and bridge materials and scrap. If a large amount of rail is to be unloaded it will pay to use two or more machines in one train so as to save switching after completing the unloading of two cars while still holding the main track. By using two machines in a train, 16 men, a foreman and an assistant foreman, can unload rails from cars at the rate of five or six a minute, providing the locomotive is equipped with a pump to furnish sufficient air pressure.

Cleaning Ballast with Locomotive Cranes and Screens in Cars.—The utilization of locomotive cranes in connection with screens in cars for the cleaning of ballast has proved that much can be saved in this way. In using these cranes a better job of cleaning is done, because when cleaning with laborers the bottom of the tie is about the limit, while with the locomotive cranes the strip between tracks on multiple track territory is dug down to sub-grade. This stone goes over the screen and all dirt is removed, leaving clean stone of the depth of the ballast for drainage. The expense of the work will be reduced by using two or more locomotive cranes.

The screen is placed on a car built for the purpose or can be built for use with any standard steel hopper bottom coal car, so that the stone goes over the screen in one pocket, while the dirt falls in the other, the stone pocket being left open and the stone falling on the track. The dirt can be disposed of on sidings or elsewhere. The cost of doing this work varies, depending upon the location, the train service and closeness to clearing points. On one railroad the following was found to be the cost, based on cleaning 25 rails lengths per day:

1 engine and crew, 10 hours	$ 85.00
2 locomotive crane engineers	10.80
2 locomotive crane firemen	6.40
8 laborers (4 per machine)	25.60
15 laborers digging out between ties (2 rails per man)	48.00
Total	$165.08
Cost per rail length	6.60

This cost, compared with $9 per rail length by hand and work train, shows a considerable saving. On another railroad the cost amounted to $3.17 per rail by utilization of the locomotive crane, screens in cars and work train, where the ballast was cleaned to a depth of 20 in. from the top of tie.

Snow-Melting Devices.—There are several devices for handling snow. One method is the use of hydro-carbon for melting snow at switches. The cost of cleaning switches by hand will average 55 cts. per switch at interlocking points as compared with 20 ct. per switch by the use of hydro-carbon. Steam heating plants are being used at terminals where steam can be piped conveniently or furnished from old locomotive boilers placed at important points and covered so that they make a desirable appearance. A steam heating plant properly operated can be run with three laborers and a foreman, whereas it will take 25 men, a foreman and an assistant foreman to keep such a place open during a severe storm. This means a saving of approximately 60 per cent.

Motor Cars.—The motor car is a great labor-saving device, especially on single track sections where the territory is long. The general use of motor cars has helped materially during the past few years in holding labor, as there has been less difficulty in holding men on sections so equipped than on sections not so equipped in the same territory.

Tamping Machines.—Tamping machines are standard on many roads today. The committee finds that some roads show great savings by the use of these machines, while investigation shows the cost of tamping ties with these machines to be little less than the cost of tamping by hand, but the work done with these machines will hold up twice as long or more under favorable conditions. The amount of labor required to tamp a given length of track is about one-half that required to tamp by hand, but the cost of fuel and operation of the machines absorbs part of this saving. The cost of tamping by hand, including lining and dressing will average 20 ct. per tie. As track tamped by machine will hold up twice as long, one tamping is saved.

In locataions where an air line exists these machines are particularly valuable. The compressors are a valuable asset when used for other purposes, such as running pneumatic drills, reamers, riveting machines, sand blasting and painting machines, pneumatic machines for bolting and unbolting rail joints, etc. They are also valuable in emergencies for operating signal lines, charging train lines, pumping water, etc.

Ditching Machines.—The steam ditcher is one of the greatest labor-saving devices where heavy ditching is to be done. With an air dump car placed on each side in a work train, it will accomplish as much in one day as 30 men will do with flat cars in 3 days. It is also being applied more and more to other uses, such as handling rail, ties and other materials, and is available in emergencies for loading coal at storage piles and for use at engine terminals in the winter. This machine has an advantage over steam shovels in sand pits and coal storage piles in that it does not require the service of a work train, for it is able to handle from 2 to 3 loaded cars under its own power, or to operate under its own power on a track parallel to one on which empty cars may be set. It can also be used for the purpose of removing drifts or ice gorges from trestles or bridges by disconnecting the clam shell or shovel and attaching a pair of car wheels on the axle to the end of the cable and dropping it on to the ice so that it can be removed in small quantities without any trouble after being broken. By breaking the ice gradually in this manner it can be handled easily.

We find that the cost of handling coal, sand, etc., averages 10 ct. per cubic yard, whereas the cost of handling this same material by hand will average 60 ct. per cubic yard. This was based on one machine handling 25,000 cu. yd. of material in one season.

Spreaders.—A spreader, when used with a work train, has performed the work of at least 20 men in disposing of material on a fill and in ditching light cuts. This, on the basis of 150 working days, would be a saving of about $9,600 in the course of a year.

Dump Cars.—Side dump cars are of great assistance for the wasting of material or the widening of fills. The type equipped with an iron apron which lets down will deposit the dirt or material to be wasted beyond the ballast or grass line. Many roads are using the steel-lined, 20-yd. dump cars for handling cinders and ashes from engine terminals. To unload cinders from old side board cars by hand, as has been the custom for years, costs approximately 50 ct. per yard, while these materials can be unloaded from dump cars for about 10 ct. per yard. This will effect a large saving in the course of a year.

Weed Killers and Oiling Appliances.—The use of weed killers should be extended and two applications be made a season, one the latter part of May or early in June and the other in September, as it is found that one application is not sufficient to sterilize the soil completely. The cost of treatment, including work train service, is approximately $32 per mile, which would make the cost of two treatments per season $64 per mile. It would be impossible to perform this work as economically by hand labor as by the application of weed killer, and in addition it represents a large saving in labor.

The Committee.—George W. Morrow (chairman), supervisor, N. Y. N. H. & H., New Haven, Conn.; J. W. Powers, supervisor, N. Y. C., Rochester, N. Y.; J. M. Fair, supervisor, Penna., Philadelphia, Pa., and C. A. Joyce, supervisor, Erie, Paterson, N. J.

Non-Spacing of Joint Ties and Non-Slotting of Joints

Committee Report Presented Nov. 22 at 40th Annual Convention of the Roadmasters and Maintenance of Way Association

At the present time all railroad managements are calling for less expensively maintained tracks, and at the same time for an improvement in the track structure. We, the actual users of the materials and labor, are expected to maintain the tracks at a lower cost. We believe that the "non-spacing of joint-ties and the non-slotting of joints" offer one of the best methods of complying with these requirements.

It is a known fact that the joint is the weakest point in railroad track. Every conceivable means has been applied to reinforce and strengthen it to make it equal in strength to the rail, but nothing that has yet been developed approaches this objective. Why, therefore, should we place an extra burden upon the joint by making it render service over and above the other portions of the rail by anchoring the track at this weak point by slotting the angle bars and spiking through the slots, which action causes the rail to drag the ties off their bed as it runs. When the ties are shifted in this manner they are lowered and cavities are created back of them in which water accumulates and causes the joints to churn, become low and battered, destroys the bolts and angle bars, and bends the rail in the short quarters if it is allowed to creep to any extent.

With non-slotted angle bars and with rail anchors placed on the intermediate portions of the rail, the joints are permitted to pass over the ties without disturbing them if the rail should creep, thereby eliminating the slewing of the ties and creating no cavities in which the water may accumulate about the joints any more than about any other tie under the rail. This preserves the angle bar and protects the bolts, which can be kept tight because of the absence of extra stress.

All ties should be spaced uniformly under the rail regardless of their position relative to the joint. In other words, one joint may be a suspended joint and the next one a supported joint, distributing the load upon the ballast and the roadbed uniformly. When laying new rail, where it is not the intention to space the ties under the joints, they should be staggered so that they will come at the centers of the old rail. If the new rail is the same length as the old rail this can be done, and will promote good riding track.

The number of rail anchors required to hold rail from creeping depends on the volume of the tonnage carried, the kind of ballast, the condition of the roadbed and the grades. Ordinarily from 6 to 8 rail anchors are sufficient to hold rail from creeping under one-way traffic, except where trains slow down or stop at stations, at which points more anchors will be necessary. Where the track is carried on peat bog or wet, unstable ground from 8 to 12 anchors may be required. On single track 2 to 4 anchors are required, these anchors being applied each way except on descending grades, where the rail usually moves in one direction, in which case all of the anchors should be applied the way the rail is creeping.

To space ties uniformly under the joints and elsewhere throughout the length of the rail where the track is given a 3-in. raise, pack tamped, will cost $840 per mile in stone ballast, while to give it a 3-in. raise in stone ballast where ties are not spaced will cost only $690 per mile, a saving of $150 per mile by not spacing ties. To space ties uniformly throughout the length of the rail in gravel ballast where the track is given a 3-in. raise, shovel tamped, will cost $700 per mile and where the ties are not spaced $570 per mile, a saving of $130 per mile by not spacing ties. These figures are based on $0.40 per hour for labor.

It will cost $0.80 per joint to space the joint ties and shift the shoulder ties where necessary in stone ballast and $0.50 per joint in gravel ballast. This is poor practice and should not be allowed on any railroad for the reason that the ties are moved off their old bed and will not be as solid as the other ties under the rail, causing the joints to become low, bend the angle bars and make bad riding track.

The saving of tie timber is also an item well worth considering. In spacing ties more or less damage is done them, which hastens the time of their removal. In spacing ties some of them are necessarily moved off their old bed, while others are not disturbed, which gives them an unequal bearing, however well they may be tamped, and requires more frequent surfacing to maintain the track at a true level.

The eliminating of the spacing can be done with the greatest safety where the track is in good line and surface. Where this condition prevails the spending of any money for the spacing of ties is largely a waste in so far as any improvement in the track maintenance is concerned.

When rail is being relaid where the track is in bad line and surface and the rail badly surface bent so that it is necessary to surface the track under the new rail immediately to prevent damage to it, the surfacing can be carried on much more rapidly if no time has to be spent on the spacing of ties.

Blasting in Quarries and Open-Pit Mines

Some interesting information on shot firing by electricity at quarries and open-pit mines was given by Mr. N. S. Greensfelder, on a paper presented last September, at the San Francisco meeting of the American Institute of Mining and Metallurgical Engineers. The note following is taken from the paper.

At open-pit mines and quarries, the usual practice is to shoot simultaneously a number of holes containing relatively large charges of explosives. Better results and greater efficiency from the explosives are obtained in this way, than if the holes fired one at a time. Simultaneous detonation may be accomplished either by the use of electric blasting caps or cordeau-bickford detonation fuse.

Where convenient it is advisable to detonate the cordeau with an electric blasting cap. The average rate of detonation of cordeau is about 17,500 ft. per sec.; when it is placed along an explosive charge in a deep hole the entire column of explosive is detonated at a rate equal to that of the cordeau. This increases the shattering effect of the slower explosives, and, consequently, decreases the cost of secondary blasting. When the explosive charge is not continuous, but is placed at different points along the hole, cordeau furnishes a particularly convenient and efficient means of firing. The charge can be broken as many times as desired, because the cordeau extends along the entire length of the hole and, therefore, detonates all of the explosive. In the deeper holes it is necessary to use countered cordeau and often advisable to use double countered cordeau neither of which break as easily as the plain cordeau.

An Ohio company producing crushed stone found that the amount of explosive necessary was reduced more than 10 per cent. by replacing electric blasting caps with cordeau. Missed holes were also practically eliminated. At the Nevada Consolidated Copper Co., where churn-drill holes are first chambered by dynamite and then loaded with black blasting powder, it has been found that the holes can be loaded more quickly and with greater safety with cordeau than with fuse and blasting caps and the danger from unexploded caps and powder in missed holes has been eliminated.

Although cordeau has certain advantgages over blasting caps in firing deep churn-drill holes, electric blasting caps are still used at many mines and quarries. Their initial cost is less and, if the work is properly done, they give good results. In holes containing large charges of explosives, a good precaution is to place two or more electric blasting caps in each hole, or two caps in each separate charge in the hole if several charges, separate by stemming, are used. If the holes are wet, waterproof caps should be used; if there is over 30 ft. of fluid in the hole, submarine electric blasting caps are desirable. Care should be taken in loading to prevent injuring the insulation or breaking the wires. Frequent galvanometer or ohmmeter tests should be made when loading large charges. Electric blasting caps should not be handled during an electrical storm, as in a number of instances they have been detonated by the lightning discharges. If the ground is damp, the joints should be taped or raised off the ground to prevent grounds or short circuits. Each circuit should be tested for resistance with a galvanometer or ohmmeter, and if a blasting machine is used, its capacity should be tested with a rheostat, before an attempt is made to fire the shot.

Hydro-Electric Power Development as Related to the Electrification of Railroads

A Paper in the Symposium on the Water Power Problem, Presented at the Fall Meeting of the American Society of Civil Engineers at San Francisco on Oct. 4-5

By C. F. LOWETH,

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The title of this paper may lead to the assumption that cheap and abundant hydro-electric power in itself would justify the electrification of steam railroads. In the writer's opinion, such an assumption would be incorrect. The electrification of steam railroads, thus far, at least in the United States, has come about more largely from causes other than cheapness of electric power. The necessity of avoiding smoke and steam in tunnels and other restricted places, and the need of increasing the capacity of tracks or other terminal facilities have generally been the determining factors which have brought about electrification. However, it is not improbable that conditions in this respect may change; doubtless, increase in volume of railway traffic and the known economies of electrification will tend to increase the use of electricity for the operation of railroads in localities where cheap and reliable hydro-electric power is available.

Something more than a mere showing of economy will be necessary to bring about a change from steam to electric operation of railroads. Electrification will involve a large increase of invested capital, and, at the same time, the retirement of many facilities which would not be needed with a change of power. Under the many adverse conditions with which the railroads in this country have contended in the past few years, their financial credit has been impaired; only a few of them have a surplus of earnings available for improvements, and the additional capital necessary therefor cannot be readily and cheaply obtained. Under the accounting rules of the Interstate Commerce Commission, the cost of facilities which are retired must be charged to profit and loss; such charges would be quite large, would be undesirable, and would have much the same effect as if they were charged to operating expenses.

The admitted economies of electrification have to contend with a constantly increasing efficiency of steam locomotives. Much study has been given to steam locomotive design with a view to greater efficiency; superheaters, stokers, better water, and many other appliances have made the modern steam locomotive a much more efficient and reliable prime mover than is generally supposed. This, together with the revision of gradients, additional and better facilities, and improved methods of operation, tend constantly to reduce the margin of economy which would justify electrification.

Some Advantages of Electrification.—Electrification has some outstanding advantages which probably never can be equaled by steam operation. Some of these advantages are the longer continuous operating periods possible with electric lomomotives, their greater power in single units, with less destructive effect on rolling stock and track than steam locomotives, the elimination of coal and water facilities, and the reduction in the number of engine terminals and the delays occasioned thereby. It is evident that these and all other advantages arising from electrification will vary with each particular railroad and for different points on the same railroad, and must be weighed as against all the factors affecting the cost of steam operation, of reducing gradients, and of increasing track and other facilities so as to cheapen present steam operation, and, lastly, the increased investment cost of electrification, including the retirement charges of facilities that would be retired. It is evident, therefore, that the cost of electric power is only one of many factors entering into the problem, but the more reliably and cheaply electric power becomes available, to that extent will it prove a favorable factor in electrification. To the extent that hydro-electric power is more readily available, more reliable, and cheaper than steam-generated power, to the same extent, approximately, will it be a more important factor. Even so, at this time it does not appear probable that the change from steam to electric operation would be justified for existing railroads, except where the volume of traffic is large, where it can be moved in large units for long distances, where fuel costs are high, and where operating costs due to adverse gradients and congestion of track and other facilities make steam operation somewhat more than ordinarily expensive.

Wherever the determining factor for the electrification of steam railroads has been the need of avoiding smoke in tunnels or densely populated terminals, or of increasing the capacity of tracks or other facilities, the insistence of the demand for the change has been so great, as a rule, that the cost of power has been only a minor factor. Generally, such cases have involved only restricted areas and have left much larger areas to continue to be operated by steam. The economies of electric operation in such cases probably would be increased materially by largely increasing the mileage of road electrically operated. The greater the extent of electrically operated mileage, the more important factor will become the cheapness of electric power.

Coal and fuel oil costs vary from time to time; in the last few years, the fluctuations have been extreme and, what is even more important and, at the same time, an indictment of American business and industrial methods, is the fact that fuel supplies have sometimes been uncertain. On the contrary, it would appear that, once the installation has been made, hydro-electric power would fluctuate as to supply within well defined limits, and that the cost, or at least the selling price, would be constant, or nearly so, for long periods. The ability to contract for an ample and reliable supply of hydro-electric power at favorable prices extending over a long term might easily prove a controlling factor in the electrification of railroads, especially for new railroads where the cost of coal, water, and engine terminal, as well as other facilities incident to steam operation, would be eliminated.

Why Sections of the St. Paul Were Electrified.—To illustrate this problem better, reference will be made to the electrification of sections of the Chicago, Milwaukee & St. Paul Ry., which is probably one of the largest electrification projects with respect to main-line mileage. Electrification was considered coincidently with the location and construction, in 1906-08, of the extension of this railway system from Central South Dakota to the Pacific Coast, a distance of about 1,400 miles. The extension crossed several mountain ranges where long and heavy gradients were necessary. Undeveloped water powers were abundant and power requirements for industrial uses were largely absent. These conditions led early to the suggestion that parts of the extension should be electrified; accordingly, the railway company acquired several water-power rights, and, at some places, located its lines with reference to the development of these powers. However, electrification was delayed, and on the completion of the railroad, it was operated by steam. It was not until several years later, about 1914, that the electrification of the section between Harlowton and Deer Lodge, Mont.—228 miles—was begun, and previous to the completion of this section, work was begun on the adjoining section from Deer Lodge to Avery, Idaho, making a total of 440 miles of main line. These sections crossed the main Continental Divide and the Belt and Bitter Root Mountain Ranges. Recently, the 209-mile section between Othello, in Central Washington, and Seattle and Tacoma, was electrified. A gap of main line between Avery and Othello (226 miles) is left, which undoubtedly would have been electrified before now, except for the abnormal conditions brought about by the World War and Federal control.

For various reasons, the railway company found it undesirable to add to and develop its own power requirements; therefore, it disposed of the power sites and made long-term contracts for power. The powers of which the railway company had obtained control were small compared with these now depended on, and the cost of their development would have been relatively much higher. They would have been subject to wide seasonal fluctuation as to quantity, and there would not have been the same high degree of reliability of power supply that exists under the present arrangement. The net cost of power to the railway company would also have been greater; at times, it would have been obliged to purchase power, and, at other times, it would have had surplus power to sell. The power now used and that already under contract for the 226 mile gap between Avery and Othello will be hydro-electric power. The contracts for power are with the Montana Power Co., the Inter-mountain Power Co., the Washington Water Power Co., and the Puget Sound Light & Power Co., the first named company supplying the greater part. All these companies control large supplies of developed as well as of undeveloped water power. The contracts for this power run for long periods. The first contracts were for 99-year terms, and the later contracts will expire practically concurrently with those first made. The cost of the current delivered at the railway company's sub-stations is the same for all contracts, and at a very low price. The several power contracts are interrelated with agreements between the several power companies which, in effect, is practically equivalent to one contract covering all the railway's requirements for the electrified section. The railway company is, therefore, depending not on the individual power resources of these several companies, but on their combined resources, as the generating stations of the companies are so many and so completely tied together as to insure an uninterrupted supply for the entire electrified section. The 18 or 20 generating stations supplying power under these contracts extend over a territory from Central Montana to Puget Sound, a distance of more than 650 miles, with a north and south width of nearly 200 miles. The drainage areas supplying these powers not only cover a much larger territory, but they also differ greatly as to climatic and topographic conditions, a factor which it is believed insures a reliability of power supply under the most extreme conditions. The combined capacity of these stations is more than 360,000 kw. Within this area, and adjacent to it, are many undeveloped water powers. There can be no question but that this combination of ample, reliable and cheap power, supplied under long-term contracts, at a low price, is an important factor in justifying this extensive railway electrification.

The other factors justifying the electrification were the remoteness from fuel supplies, the long stretches of steep gradients, the character of freight traffic, which permitted it to be concentrated in large train units, the considerable mileage of railway electrified, and, last, but not least, the fact that the railway company would be able to control the flow of traffic over the electrified sections in such manner as largely to eliminate extreme peak loadings. All these last named considerations, of course, would apply more or less equally to an electrification using steam-generated current.

In this connection, it is interesting to note that this railway prior to electrification used oil for locomotive-fuel purposes exclusively for the main line and for the branches from Deer Lodge to the Pacific Coast, the oil being shipped by water from the Southern California fields. At that time and for a period of several years, oil was cheaper for the railway than coal, and had the further advantage of minimizing fire risks, an important consideration because the line crosses several forest reservations. Later, for those sections of the railway that were not electrified, it was necessary to change from fuel oil to coal.

Of the various electrifications of steam railroads in the United States, the majority are using steam-generated current. The several electrifications centering in and about New York City, the Pennsylvania Ry., at Philadelphia, Pa., and its West Jersey & Sea Shore Ry., the Norfolk & Western Ry., the Detroit, Sarnia, Hoosac, and Baltimore Tunnels are all operated by steam-generated current. Both steam-generated and hydro-electric currents are used for the Canadian National Ry. Tunnel at Montreal, Que., mostly the latter, whereas for the Great Northern Ry. Tunnel in Washington only hydro-electric current is used. The Butte, Anaconda & Pacific Ry. (which carries a heavy freight traffic) and the Spokane & Inland Empire R. R. lines use hydro-electric power exclusively, the former being supplied by the Montana Power Co.

Electrifications in Foreign Countries.—The abundance and cheapness of hydro-electric power, especially as compared with steam-generated power, have probably been more the controlling factors in the electrification of steam railroads in foreign countries than in the United States. This is shown in the official reports made to the International Railway Congress held in Rome, Italy, in the early part of 1922. As to Sweden and Norway, Mr. Ofverholm, chief of the Electrical Department of the Swedish State Railways, and official reporter to the congress, states:

"Sweden, Norway, and Denmark have not the necessary quantity of home-produced coal. The coal fields that exist in the south of Sweden are quite inadequate, and the coal is of poor quality. On the other hand, Sweden and Norway have plenty of water power, though this is not the case with Denmark. In the first two countries, railway electrification on a large scale has been contemplated, in order to utilize water power instead of depending on imported coal. In Denmark, owing to the lack of water power, no such schemes are in existence.

"The desire to make the railways independent of foreign coal has been entertained in Sweden for a long time."

Later in the report, where the program for electrification is being considered, he states:

"The chief point is to make the railways independent of foreign coal: therefore, the lines that have the highest coal consumption should be the first to be electrified." . . . "The research work carried out in connection with the electrification has included an investigation of the total amount of hydraulic power available."

The reporter for Italy, Mr. Alfredo Donati, states:

"The new program for the extension of electric traction in Italy which was drawn up by the Administration of the Italian State Railways in common with the Government, anticipates the electrification of about 2,800 miles of railway which has been selected with care from amongst those which, owing to their gradients and their heavy traffic, now consume the greatest quantity of coal."

It was stated that this program when completed will effect an annual saving of about 1,250,000 tons of coal and a consumption of about 600,000,000 kw.-hr. of current per annum, the greater part of which will be generated by water power. This program, however, is not altogether to save coal, for, later, it is stated that, on certain of the lines to be electrified, the limit of traffic which could be carried by steam traction, had been attained, and electrification had become necessary for increasing the carrying capacity of the lines; also, that, on a number of Italian lines, electrification has been hastened on account of the difficulties of steam operation through the numerous tunnels.

The Federal Railway Commission of Switzerland, reporting to the International Congress, concludes with the following statement:

"The electrification of the Federal Railways is an economic necessity, and ought to be brought about if regular working at all times and under all conditions is to be assured. We must not forever remain dependent on foreign countries, which may withhold their coal, or at any rate dictate their prices without consideration for us. Of the total imports in 1920 (approximately 991,700 tons), 303,914 tons or 30.5 per cent, came from England, and 553,986 tons, or 55.9 per cent, from America, while our former principal sources, Belgium, the Sarre Territory, and the Ruhr Valley, only delivered to us altogether 65,500 tons, or 6.6 per cent. This fact shows on what casual conditions our coal supply, and, consequently, the working of our railways, depends, without taking into account the disturbing factors arising out of strikes, transport difficulties, etc."

France, according to M. Sabouret, chief engineer, technical department of the Orleans Railway, reporter to the International Congress, has an ambitious electrification program. In addition to some electrification already completed, and the program for the state-owned railways, the Orleans Ry. Co. has a program for the electrification of 1,240 miles of railroad, the Midi Railway for 1,680 miles, and the Paris-Lyons-Mediterranean Co. for a considerable mileage.

The Orleans Ry. will use largely hydro-electric power supplemented with some steam-generated current from a station near Paris; the Midi Railway will use largely, if not exclusively, hydro-electric power; the Paris-Lyons-Mediterranean Co. will obtain its principal sources of current from hydro-electric plants on the Upper and Middle Rhone River. All three railways will develop their own power, and, in some cases, the developments will be made jointly with the state-owned railways. These three railways have under consideration a plan for the joint development of hydro-electric power on the Truyere River, in which the development would exceed 200,000 HP., the supply being exceptionally regular. The plan is to divide the power between them in such a manner as to supplement for each railway the minimum power from its own stations during periods of low water. The reporter says:

"The flow of the watercourses of the Central Plateau is complimentary to those of the Alps and Pyrenees; the Truyere will feed the Rhone and Garonne basins during the winter, and the Central Region during the summer. This large program of the organization of hydro-electric energy shows clearly the obligation imposed on the three companies of associating themselves in a work of unification required in the national interest and to promote the linking up of the three great producing districts."

These references are illustrative of the development of the electrification of railroads in other countries; they appear to indicate the probability that hydro-electric power, by virtue of its cheapness and other qualities, has been more of a factor in extending electrification in foreign countries than it has been in the United States.

The Pacific Coast, with its vast hydro-electric power potentialities, seems to present favorable conditions for the electrification of steam railroads. The power possibilities are probably in excess of commercial and industrial needs and are likely so to continue, whereas coal and fuel oil supplies are becoming more costly and less certain. The topography of much of the country traversed by the railroads and the extent and character of the traffic result in railroad-operating conditions which probably could be met more economically by electrification than by steam.

Advantages of Electrification for New Construction.—In the case of new railroad construction, assuming that, in spite of excessive and oftentimes conflicting regulation of the railroads by Federal and state authorities, capital for new railroad construction can be found, electrification would offer advantages for such lines as have promise of a reasonable volume of traffic. The saving in first cost of water and fuel facilities and in the fewer engine terminals required would be considerable, and it is probable that the location of the line and the ruling gradients adopted would be such as to reduce the cost of construction as compared with a road intended to be operated by steam.

It is possible that the requirements of the Federal Water Power Act may make it impossible to contract for power for periods longer than 50 years at the most, and together with state regulation of public utility rates, may make uncertain the permanency or uniformity of power rates extending over long periods; if so, the progress of railroad electrification may be somewhat retarded.

The subject of this paper has been covered in such a brief and general manner that no conclusions are warranted. However, it would seem reasonably safe to assume that hydro-electric power would be an important factor in steam-railway electrification under the following conditions:

(a).—When cheap and available over such an extended area as would include a large main-track mileage for the individual railroad under consideration.

(b).—When supplied from several sources tied together so as to insure reliability.

(c).—When it can be contracted for long periods.

(d).—When its cost reduced to terms of locomotive tractive effort, is cheaper than that of steam-generated power

Constructive Measures Needed for the Railways

From the Recently Issued Annual Report of Herbert Hoover, Secretary of Commerce

Our transportation facilities have lagged far behind the necessities of the country. Progress has been made in their restoration from the demoralization of war, but our rolling stock, our trackage, and many of our terminals are unequal to our needs. Some increases in equipment have been made during the past year; yet they are entirely insufficient as the result of long-continued financial starvation. The deficiency in transportation finds its visible expression in car shortage; and while the recent strike has temporarily aggravated the situation, the trouble is far more deep-seated. Except during periods of business depression or strikes there has to some degree been continuous car shortage for the last six years. Furthermore, car shortage reaches its most acute stage during the four or five months of peak load in the fall and early winter.

Short Transportation and Price Levels.—Railway cars are the red blood corpuscles of commerce, and we suffer from commercial anemia every year, because they are starved. The losses through short transportation are a tax upon the community greater than the cost of our Government, because such a shortage not only stifles the progress of production and introduces speculation into distribution, but it also seriously affects price levels. No better instance exists than the lift in the price of coal by over 300 per cent in 1920, when there was no strike, and over 60 per cent in 1920, after production following the strike had been resumed. In both cases the mines could have produced 30 per cent more coal, and if the railways could have transported even 20 per cent more, then prices would have been normal. Furthermore, this very shortage is one of the most deep-seated causes of the instability in the bituminous industry and its recurrent strikes. The car shortage also directly affects our farmers, because in every car-shortage period a price differential on grain below the Liverpool price (and yet in excess of the railway rates and handling costs) sets in of from 5 to 15 ct. per bushel. The losses to live-stock growers are very great because of the necessity to feed stock beyond the fattened stage. And there are regularly great losses in fruit and vegetables because of the lack of refrigerator cars.

Our Railways Most Efficient in World.—The management of our principal railways today, by all the tests of administration, of load factors, of mechanical efficiency, etc., is the most efficient transportation machine in the world in so far as it is not limited by causes beyond the managers' control.

The situation has been contributed to by the war, but also fundamentally by the cumulation of experiments in public relations to the railways, both national and state. We have tried uncontrolled operation; we have tried negative regulation in the prevention of discrimination; we have tried nationalization; we are now trying positive regulation. Nationalization would be a social and economic disaster; free operation would reconstruct the vicious practices of 30 years ago. Regulation in some form is necessary, but constructive development of this regulation—to preserve the initiative and responsibility of our railway executives, to secure the fine values of private operation, and at the same time to secure public protection and assure adequate service—is absolutely vital and not necessarily incompatible. The present transportation act possesses many constructive features and some weakness. It was the result of compromises in many particulars, and these very compromises are some of its weakest points.

The Fair Return Section of Transportation Act.—If the causes of financial starvation were solely a question of war and of hard times, we could afford to wait for a natural solution, but they are not. The Transportation Act of 1920 affirmatively declared that the rates should yield a fair return on the aggregate real value of the railway properties (as determined by the Interstate Commerce Commission) used in public service and operated under honest, efficient, and economical management. It provided that the fair return during the first two years should be at the rate of 5½ per cent on the railways as a whole, or in each of the major groups in which the country might be divided in the administration of the law, and that during this period there might be added 1½ per cent for rehabilitation. At the expiration of this two-year period the Interstate Commerce Commission placed the fair return at the rate of 5¾ per cent per annum, or 6 per cent less one-fourth per cent to cover income taxation. The law, however, further provided that any particular carrier which earns in excess of 6 per cent per annum shall hand over one-half of that excess into a contingent fund to be administered by the Interstate Commerce Commission "in furtherance of the public interest in railway transportation" either by loans to carriers or by the purchase of transportation equipment and facilities and the leasing of the same to the carriers. The carriers have never earned these amounts and the failure of earnings without charge on the Government is complete disproof of the current fiction that earnings are "guaranteed."

Weaker Roads Unable to Earn Up to Average.—Furthermore, the immediate effect of this recapture provision would be that whereas the strong and fortunately situated railways are able to earn in excess of 6 per cent, and are therefore able to secure finance for betterments, the very fact that they did earn in excess of the average would mean that the weaker roads were unable to earn up to the average. It may be accepted as a general proposition that carriers earning materially below the 5¾ per cent return are not in a position to command the confidence of investors which is necessary for expansion to meet the public demand. The contingent fund makes available money which such carriers may borrow, provided, however, that they are able to give the necessary security for repayment. It is easy to comprehend that such a contingent fund may serve the purpose of bridging carriers over temporary difficulties, but it is more difficult to understand how a carrier which, though it may be very essential to its part of the country, is financially a chronic weakling, is to be made strong and capable by becoming more deeply involved. If there is any merit in this device, it seems not to extend to those anaemic carriers that are unable to give the Government the color of assurance of repayment. This device also carries a certain liabiilty to the Government in that carriers that borrow from the fund and fail to pay are likely to become Government railways through their financial difficulties. It would seem that the first of the two uses to which moneys of the contingent fund may be put holds out better promise of furtherance of the public welfare. However, the creation of such a national reserve of transportation equipment has not been seriously undertaken. It would seem that our dire distress in time of car shortage and at times, motive-power shortage would strongly argue for the creation of such reserves. Rolling stock for limited use during 60 to 90 days is probably unprofitable to any railroad, and certainly the stronger railroads can not, and should not, be expected to provide it for the weaker ones.

Consolidation of Stronger and Weaker Roads.—The present act contemplated the solution of the problem of the weak roads through voluntary consolidation of the weaker and stronger roads into larger systems to be definitely indicated by the Interstate Commerce Commission. There is no doubt that such consolidation would be a large advance in solution to the whole problem. As the nation has resolved to control rates, and thus to depend no longer on competition as a means of rate regualtion, it should secure the manifest advantages of larger systems. The economies in operation through the standardization and better employment of rolling stock would be constructive themselves, but of vastly more importance would be the strengthening of the foundations for the financing of betterments and for more intelligent handling of rate regulation. The part of the act providing for consolidations has not been advanced very much so far, although a tentative plan of grouping has been issued to serve as a basis for investigation, and hearings have been begun. When the permissible consolidations are once enunciated it is possible that some railways can arrange terms amongst themselves for such consolidations.

How far such voluntary action would solve the problem is uncertain, but compulsory consolidation leads into many untenable premises. It might be that there could be invented some inducements to consolidate into the proposed systems, or to lease for consolidated operation, or some form of co-operative operation. If the recaptured profits principle is to be maintained and if it can be enforced by the Interstate Commerce Commission, the assured application of such recaptured profits within such enunciated groups in some form might at least be worth discussion as an inducement to consolidate.

Control of Rates.—The alternative of repealing the miscalled guaranty clauses of the act does not fundamentally assist the expansion of the weaker roads, for so long as rates are controlled by 49 different commissions, it is unlikely that the rates would or could be made discriminatory in favor of the weaker roads, and thus the basis for the financing of betterments by these roads would not be materially improved. The suggestion that all rate control should be repealed except control against discrimination or preference would not meet the situation of the weaker roads, because the restoration of competitive rates would enable the stronger roads to again drive the weaker roads nearer to the wall.

Another vivid question in this connection is that of the rates themselves. In an era of wide disparity between farmers' incomes and that in and of industry, the transportation rates have proved to be a heavy burden on agriculture. On the other hand, under present conditions railway earnings are obviously not large enough to assure railway expansion. Some relief both to the railways and the farmer may be obtained by thorough reorganization of the rate structure. Some classes and areas of traffic are carried at actual loss; others are carried at lower rates than the relative value of the commodities warrant; and a series of scientific upward readjustments should be made in some cases in order to give the railways and the shippers of primary commodities and agricultural produce some relief. The recent reduction of 10 per cent in rates on luxuries as well as on primary goods contributed nothing to commerce and impoverished the railways just that much. The tangled skein of rates seems a mesh in which there is so persistent a resistance against every constructive proposal, that we are incapable of rescue except by some complete departure in courage.

Wage Control and Strike Prevention.—Another phase of present regulation is the machinery of wage control and strike prevention, which is unsatisfactory. The legislation embraces the important principle of the public's right to secure continuity of service and it carries the obligation of the public to secure just wages to the employes. The Railway Labor Board has performed large services to the employes, to the railways, and to the public. The difficulties arise from the tripartite structure of the board under the act, from its detachment from the rate-making body, and especially from the fact that the act did not orginally contemplate that the Government would be a universal wage fixer. It was the assumption that the Labor Board would only function in case of a major threat of stoppage in service. The failure of the local adjustment boards for direct contact between employes and employers has thrust all disputes on the Labor Board; and in result we have practically governmental fixing of all wages and conditions of labor with a large destruction of personal contracts.

There can be no question that action in some direction is imperative, if industry and commerce are not to be further strangled by a shortage in transportation. Whatever may have been the sins of railway finance in the last generation, we are not only suffering from them, but we have maintained an attitude of bitterness in our public relationship to our railways for which we pay thrice over in prevention of their proper development.

We must have increased transportation, if we are to maintain our growing productivity. We must therefore find a way out of the cycle of systematic starvation of a large part of our mileage and the denudation of our railway managers of their responsibilities and initiative.

Railway Earnings in November.—Figures issued by the Interstate Commerce Commission show that in November the class I roads had a net railway operating income of $78,869,000, which represents a return of 4.3 per cent on a fair valuation of $19,412,201,000 as of Dec. 31, 1921, this computation being on a seasonal basis which assigns to November 9.4 per cent of the year's income. To produce returns of 5¾ per cent would have required $105,033,000 net for that month, so the shortage for November was thus $26,000,000. For all of 1922 the net railway operating income is estimated at $760,000,000, which is 4.05 per cent on the tentative valuatidn of $18,900,000,000 made by the commission in 1920, and 3.9 per cent on the property value as it now stands.

Research Fundamental for Hudson Tunnel Design

How Tests Were Made to Determine Physiological Effect of Exhaust Gases and the Proportion Ducts and Orifices in Ventilation System of World's Largest Vehicular Tunnel Described in December Issue of Mechanical Engineering

The method of handling the ventilation problem in the projected Interstate Tunnel under the Hudson river connecting New York and Jersey City is a fine example of the modern way of securing by rigorous research the fundamental facts for the solution of a big engineering problem, difficult not only because of the unusual size of the undertaking, but because there was a comparative lack of exact information as to the technical factors involved.

In the first place, the tunnel is much larger than anything of the kind ever undertaken before. The only vehicular tunnels even approximately comparable to the Hudson river tunnel are the Blackwall and the Rotherhithe tunnels under the Thames river in London. These have, however, an under-river length of only 1,221 and 1,570 ft., respectively, and carry a traffic of less than 100 motor vehicles each per hour, whereas the Hudson river tunnel, to be 8,300 ft. long, is designed to handle in excess of 2,000 motor vehicles per hour, or more than 20 times as many as the London tunnels, where, it may be stated, atmospheric conditions are reported to be bad at times.

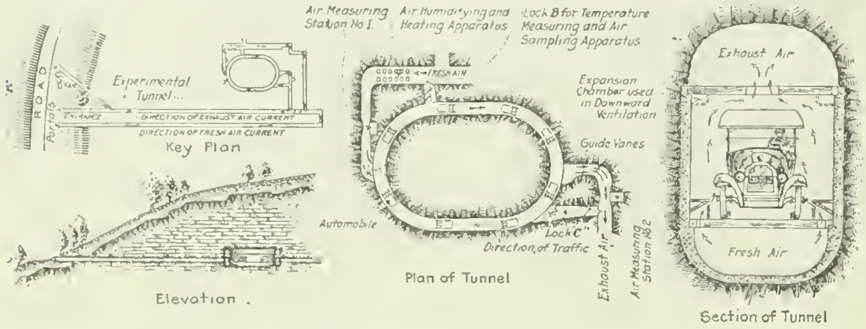
Air Measuring Station No I.
Air Humidifying and Heating Apparatus
Lock B for Temperature Measuring and Air Sampling Apparatus
Experimental Tunnel
ROAD
Portals
Entrance
DIRECTION OF EXHAUST AIR CURRENT
DIRECTION OF FRESH AIR CURRENT
Key Plan
FRESH AIR
Expansion Chamber used in Downward Ventilation
Guide Vanes
Automobile
Lock C
Direction of Traffic
Exhaust Air
Air Measuring Station No 2
Plan of Tunnel
Elevation
Exhaust Air
Fresh Air
Section of Tunnel

Fig. 1.—Experimental Tunnel Constructed in the Room Workings of a Coal Mine at Bruceton, Pa.

Elements to Be Determined for Ventilation System.—There were three elements to be determined before a comprehensive design of the ventilation system could be worked out. First, it became necessary to determine the amount and composition of exhaust gases from the motor driven vehicles which were to pass through the tunnel at a known rate. The next problem was to find out what quantity, or rather percentage of these exhaust gases in the air would be harmful to persons spending the time in the tunnel necessary to pass from one end to the other, taking into consideration various possible delays. With these two factors known, it became a simple mathematical problem to find out how much fresh air must be introduced into the tunnel to produce the necessary dilution and render the exhaust gases harmless. Finally, it was necessary to determine the complete design for adequate ventilation and, to be on the safe side, actually try it out before an irrevocable commitment was made to its use in the actual structure. It was neither an easy nor a simple matter to obtain information on all these factors, but it was obtained, and American engineering may be justly proud that all the tests were carried out in a scientific manner and with a considerable degree of precision in institutions located in this country, and largely with apparatus developed in America.

Tests at Pittsburgh Station of Bureau of Mines.—A series of tests were carried out at the Pittsburgh Experiment Station of the Bureau of Mines in accordance with the program of the Chief Engineer of the Tunnel Commission. A number of passenger cars and various kinds of trucks and busses were tested both under summer and winter conditions on a level course and over various grades. The exhaust gases were carefully analyzed and it was found that the percentage of carbon monoxide for all classes of vehicles varies within wide limits and depends on a number of variables. The effect of carburetor adjustment is probably directly or indirectly far greater than that of any other factor. It was also found that because of improper adjustment—something quite common with the average automobile driver—there is an immense waste of gasoline from the resulting excessively rich mixtures.

In the tests the average output of carbon monoxide for each class of motor vehicles under certain conditions was determined, and this together with a knowledge of the vehicle capacity of the tunnel gave a fairly clear idea as to the maximum volume of toxic gases with which the ventilating engineer must reckon.

Physiological Effects of Exhaust Gases.—This part of the investigation was carried out at the Laboratory of the Bureau of Mines at Yale University with Yandell Henderson in charge. The Bureau of Mines has had considerable experience in this kind of work, as it had already undertaken studies which dealt with the use of traction engines in coal mines, the vitiation of air in small garages and coal mines, and the determination of standards for the vitiation consistent with safety.

Prior to this investigation the standards of allowable air vitiation with carbon monoxide had not been precisely defined. Dr. J. S. Haldane, in England, had investigated the question chiefly with reference to the safety of miners after mine explosions and fires and his attention had accordingly been directed to the amount of carbon monoxide which would incapacitate or seriously inconvenience a man, rather than to those amounts which are compatible with complete comfort and efficiency.

The simplest way to deal with this question would be to demand that the air in the tunnel be as pure as that of the city streets, with a standard of, say, not more than one part of carbon monoxide in 10,000 parts of air. This standard would not be economical, however.

Carbon monoxide when inhaled produces oxygen deficiency in the body which leads to physiological results that vary with the length of exposure and the concentration of gas. This latter, it may be stated, is commonly measured and expressed for purposes of ventilation as one or more "parts" of this gas mixed with 10,000 times as much air, one "part" being therefore one-hundredth of one per cent of the atmosphere.

The absorption of carbon monoxide by the hemoglobin of the blood proceeds at first at a very rapid rate, but slows down as time goes on, and the more carbon monoxide the blood absorbs the greater becomes the force with which this gas tends to diffuse out again into the air, the condition gradually approaching a state of equilibrium, though it is not certain to what extent it ever reaches it. As a definite quantity for determination may be selected the time required for an attainment of a percentage saturation of one-half the equilibrium values. Thus, in an atmosphere containing two parts of carbon monoxide for which the blood equilibrium is about 28 per cent, the length of time that would be required for the blood to become 14 per cent saturated, and so on for other concentrations and percentages of saturation.

The answer to this question is the principal practical contribution to knowledge that has been made. Experimentally it has been found that the time for attainment for half-equilibrium for persons sitting at rest and breathing concentrations of carbon monoxide up to 7 per cent is never much less than one hour, and what is more, it has been established experimentally and by analysis of reasonable conditions that the vast majority of people who may travel through the tunnel under conditions of actual operation can be safely assumed to fall within these limits.

How the Tests Were Made.—The method of studying the effects of various concentrations of carbon monoxide which has been found to be the most reliable for establishing standards of permissible vitiation of air is illustrated in Fig. 2, which shows a chamber of 226 cu. ft. capacity. The walls and door of this chamber are made gastight to such an extent that it will hold any concentration of gas for a day without any appreciable less from diffusion through undiscovered leaks. A small hole in the door allows the hand of the man inside to be thrust out for the withdrawal of blood.

Measured amounts of pure carbon monoxide were introduced into this chamber and in turn the members of the investigating staff and a few other persons spent periods of one hour therein after amounts of carbon monoxide from two to eight, and in one case ten, parts were introduced. While they sat and read most of the time, there were a sufficient number of activities, such as turning on the electric fan, standing up to look out of the window for a moment, opening and closing flasks to take air samples for later analysis, etc., to correspond fairly well with those of the driver of a car. Blood to the amount of 20 to 30 drops were drawn from a finger before the subject entered the chamber and 0.02 cc. were drawn in the middle of the period and at the end, and usually once or twice during the three hours following the subject's leaving the chamber. These blood samples were analyzed for carbon monoxide, in addition to which certain checks were used and other observations taken. Of all signs and tests both in the experiments in the chamber and other tests, the typical carbon-monoxide or oxygen deficiency headache proved the most definite and reliable. It is a distinctly localized pain, usually frontal, throbbing, intensified by lying down or by exertion, and accompanied by certain effects, such as nausea, etc.

Results of the Tests.—As a result of these tests it was found that if at any point the concentration exceeds six parts of carbon monoxide in 10,000 of air, men doing hard work for even a short time will be unfavorably affected. A study of the traffic conditions expected to obtain in the tunnel has shown that even slow-moving trucks, allowing for all possible ordinary delays, will pass through the tunnel in less than 45 min., and a degree of concentration has been determined which will provide not only complete safety but also an assurance of freedom from disagreeable effects due to the presence of carbon monoxide. There are, of course, other features, of tunnel ventilation, for example, wind velocity, moisture, temperature, etc., which have not been specially investigated in the present instance, but enough is known about them to permit intelligent design of the ventilation apparatus.

Tests Under Tunnel Conditions.—One is strongly impressed with the thoroughness of the tests carried out in this connection. For example, in addition to tests in the small chamber described above which involved exact but rather artificial conditions, another series of tests were carried out with actual exhaust gas and under conditions as near as possible to those that will be encountered in the tunnel when completed. For this purpose a hip-roofed brick building 30 ft. by 30 ft. with walls 12 ft. high was erected. Its cubic capacity was approximately 12,000 cu. ft. of air, which is about the volume of the vehicular tunnel required for two cars when the traffic is active. A Ford car was installed near the middle of this chamber with a dynamometer arrangement that permitted the engine of the car to run at a fair load and to expend the power in mixing the air in the chamber.

In this chamber groups of a dozen or more persons at a time sat or moved about for periods of one hour. In addition to the staff of this investigation a number of students of the Yale Medical School, both men and women, served as subjects. After the tests the general condition and feeling of the subjects, particularly the occurrence or absence of headache, were noted and other observations taken, proper gas analysis being carried on all the time. A few observations were also made on two horses, and dogs were subjected to high concentrations of gases, various bases besides carbon monoxide and exhaust gas being used for this purpose in order to obtain as extensive result as possible.

The Mechanism of Ventilation of the Tunnel.—With the completion of tests at the Bureau of Mines Laboratory in Pittsburgh and the Physiological Laboratory at Yale University, the tunnel engineers had a fairly clear idea as to the problem that lay before them. From the number of cars for which the tunnel was designed and the volume and composition of gases found in the exhaust, the amount of toxic gases was known, while the Yale University tests established a standard for the permissible content of carbon monoxide and similar constituents in air. From this it was quite simple to determine the amounts of air per unit of time to be supplied to the tunnel in order to maintain the proper ventilation. In a smaller installation this would have ended the necessity for further investigation. In the present case, however, it became necessary to go a step further and determine such things as the coefficient of friction for flow of air in concrete ducts; the laws governing the flow of air in concrete ducts of uniform cross-section with the air leaving or entering in uniform quantities at uniform intervals; and finally the power losses in bends or elbows in concrete air ducts. This part of the work was conducted partly at the Bureau of Mines and partly in a special experimental plant at the University of Illinois, Urbana, Ill., under the direction of the Chief Engineer of the Commission or his representatives.

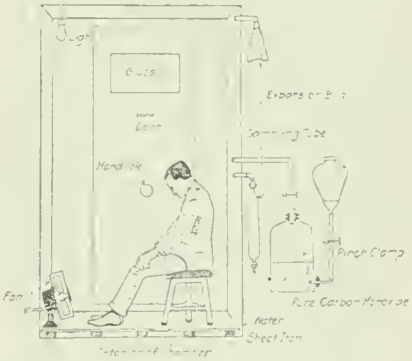

Fig. 2.—Chamber Used in Studying Effects of Various Concentrations of Carbon Monoxide.

Extensive tests carried out at the University of Illinois gave sufficient information as to the behavior of the air under the various desired conditions and permitted the derivation of equations for blowing or exhausting air through a duct in uniform quantities at uniform intervals. These made it possible to compute the air horsepower required.

Ventilation Tests in Experimental Tunnel.—With the conclusion of these tests, what might be called the scientific foundations for the design were laid down. In view of its unusual size and the novelty of some of the elements involved, it was obviously desirable, if possible, to test out the relative merits of various methods of transverse or distributive ventilation, introducing fresh air through the bottom duct and exhausting through the top duct and vice versa. Experiments were accordingly conducted in an experimental tunnel constructed in the room workings of a coal mine at Bruceton, Pa. (Fig. 1). The reason for constructing the experimental tunnel underground was to secure a location that would be free from atmospheric disturbances and to obtain data on the flow of heat through the walls of the tunnel.

The tunnel had a driveway 8 ft. high by 9 ft. wide with continuous air ducts above the ceiling and below the roadway. The ducts under the roadway and the walls of the driveway were of concrete construction. The tunnel was oval in plan, giving a roadway length of 400 ft.

The quantity of aid was measured before entering the tunnel ducts and on leaving at two specially constructed air measuring stations in the mine passages. Samples of the air were taken at various points in the tunnel driveway and thermocouples were installed to obtain the temperature of the incoming and outgoing air, the temperature of the tunnel atmosphere, and the rate of flow of heat through the tunnel walls. Smoke observations were made by means of an optical instrument and by the Ringlemann chart. Physiological data were taken by various means.

Cars were run in the tunnel so as to give conditions as nearly as possible approaching those that would prevail in the Hudson tunnel and it was found that smoke in the tunnel atmosphere under ordinary operating conditions was not dense enough to interfere in any way with driving or comfort. It was also found that ventilating upward with openings over the center of the roadway gave better results than exhausting through continuous slots in expansion chambers located just under the ceiling at the two sides over the driveway. In downward ventilation better results were obtained by introducing the fresh air horizontally than by introducing it at an angle of about 45 deg. through the expansion chambers. The tests demonstrated that with upward ventilation the exhaust gases crossed the breathing plane of persons using the tunnel but once, while with downward ventilation they crossed this plane twice. The chemical analyses of the tunnel atmosphere also showed a lower concentration of carbon monoxide at the breathing plane with the upward than with the downward ventilation. It was therefore concluded that transverse upward ventilation is the proper method.

Experiments in the concrete model duct and elbows, together with the experiments in the experimental tunnel under actual operating conditions, have given sufficient data to determine the power required to operate the fans for ventilating the tunnel and indicate that the mechanical ventilation of the tunnel as planned is assured of success.

General Plan of Ventilation Adopted.—The general plan of ventilation adopted is as follows: Blower fans located in buildings over the four shafts will supply the required amount of fresh air to the main fresh air ducts located under the tunnel roadway. The air will then pass through flues to continuous expansion chambers, one on each side of the roadway, thence through a continuous slot to the roadway. The air remains in the tunnel an average of 1½ min., during which time it slowly ascends from the roadway to the ceiling. Exhaust fans located in the same buildings with the blower fans will draw the vitiated air through ports in the ceiling and thence through the upper duct, delivering it through stacks to the outer atmosphere. In this way fresh air will be supplied in the proper amount to all points throughout the tunnel. There will be no discomfort or danger from high velocity air currents and the exhaust gases will be quickly diluted and removed.

There is one feature in this work which deserves mention and that is the clear realization of the fundamental idea that the safety and even comfort of those riding in the tunnel must be carefully considered.

Smoke and noxious gases, though of different character, have always been present in railroad tunnels, especially those of considerable length, and have made travel in them anything but pleasant. When these tunnels were built, however, the idea of caring for the comfort of passengers to the extent of providing them at all times with clean air had not yet been conceived. Those who had to travel could not avoid riding through the tunnels, and whatever discomfort they experienced did not seem to affect the business of the railroad companies. Had the Hudson tunnel been built 25 years ago perhaps the same conditions would have prevailed, and the question of ventilation would have been handled in some hurried and ineffective fashion. It is, therefore, with sincere pleasure that one records an enlightened attitude toward the design of public utilities in which an earnest effort is made to provide decent atmospheric conditions.

The Human Problem in Industry

Abstract of An Address Presented Dec. 6 Before a Joint Session of the American Society of Mechanical Engineers and the American Economic Association

By E. M. HERR.

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The human problem in industry is not a new thing. During a thousand years of ancient times, for the most part before the Christian era, self-supporting, self-regulating organizations of workmen existed which were remarkably similar to the trade unions of today. They were publicly acknowledged and legislative enactments made to control them. But they were weakened under the reigns of successive tyrants and finally lost with the Christian massacres of Diocletian in the early part of the fourth century and the subsequent feudalism of the dark and middle ages. The immediate cause of the destruction of these far-reaching labor organizations seems to have been the coveting of their wealth and power by the rulers of the day.

Constantine in A. D. 337 recognized 35 crafts—architects, brass and copper smiths, blacksmiths, carpenters, decorators, doctors, founders, fullers (cloth), furriers, glaziers, goldbeaters and gilders, goldsmiths, ivory workers, joiners, looking-glass workers, lapidaries, masons, marble cutters, plasterers of various kinds, pearl and filigree workers, potters, painters, plumbers, pavers, sculptors, silversmiths, stonecutters, statuaries, veterinaries, wagon makers, workers in mosaic. There were many strikes, usually called historically, when they attained sufficient proportions, "servile wars." The greatest and last of these was the uprising led by the gladiator Spartacus. Practically all ended disastrously.

And so the tide of the human element in industry has ebbed and flowed through the centuries. The so-called English (industrial) revolution in 1760 marked the beginning of the factory system and a departure from isolated craftsmanship under oppressive landlordism.

As late as 1820 less than 5 per cent of the American people lived in cities with a population of 8,000 and over. Today we are the greatest manufacturing nation in the world and over half of our population are city dwellers. In Massachusetts from 1800 to 1815 laborers received from 35 to 75 ct. a day; carpenters and blacksmiths about $1, and women employed as domestic servants their board and 50 ct. a week.

About 1825 occurred the first strike for a 10 hour day. "Sweatshop" methods had then begun. Local trade unions sprang up more or less intermittently early in the century, principally in the shoemakers' and printers' trades, both for mutual benefit and insurance, and for the reduction of working hours and the increase of wages, but it was not until the fifties that national organizations began to take effective form. These were pretty well shattered by the depression preceding the civil war and did not really come into being until the seventies and eighties.

Let us now turn our attention more directly to this problem in an endeavor to ascertain at least some of the directions toward which its solution trends. The principal new thing about the problem is that industry is now conducted on a scale larger than ever known before. The problem has been intensified by the greatly increased size of manufacturing establishments, by the concentration of population in cities, having a large foreign element of often radical tendencies, and by the insecurity of employment, in which business cycles play a large part.

Cause of Labor Unrest.—The underlying labor unrest and distrust are born of fear and misunderstanding—fear of coercion, unemployment and sickness—and a lack of mutual confidence as between employer and employed. There is more liberty and consideration for the workers than has ever been known before, and with it has come to the workers the greater vision of what they believe should belong to them in welfare and happiness. The social responsibility of management is being emphasized as never before. The awakened worker of today, more sensitive than his predecessors, intelligent, critical and perhaps irritable, must be convinced of the ability of the management as well as its good faith, and in extreme cases even of the necessity of its being.

It is said that Democracy without management reverts to despotism on the mere ground of its inefficiency, and that the fundamental error in the recent Russian failure was confiscation of the factories and the expulsion of the managers, with the resultant breakdown of discipline and credit, on a false theory that labor alone creates wealth, whereas management, with credit and good faith, is of the first importance in the process of production.

It is the duty of the management of today to prove its "reason for being," and that the collective result of the combined efforts for managers and workers is a fine and great thing. If they can feel that this is the case, most men will toil cheerfully as subordinates. The management must convince employes by their experience that their treatment is fair and honest and without "bluff." It takes time to establish such confidence, and men will discover very quickly if the "boss" is not square. It must be established that labor and management are not foes.

The personnel department is now becoming common, but its intelligent expansion still has far to go and it is regrettable that some companies have seen fit to curtail this activity in times of depression when they and their men need it most. These relations should not be handled and directed by the personnel department alone. The active heads and real managers are the ones on whom this responsibility must rest and who must handle it with their employes, not occasionally nor spasmodically but regularly and continuously, for work of this kind requires a great deal of time and patience. This effort on their part will gain the confidence of the employes and instill a spirit of cooperation throughout the organization, and it must be exerted on those directly in charge of the daily work of production. Anything less than this is futile and doomed to failure. Boards of directors must keep in mind this relation and work with the officers in determining policies which the managers can carry out without destroying valuable relations established only after long and patient work and almost impossible to renew.

Experience With Shop Representation Plans.—One very large organization cites good results of five years' experience. They find that if the men are free to make suggestions to the management they will not ask an outsider to do it for them. They find that workmen are anxious to learn if given a chance, and they encourage the study in factory schools of the work of other departments. This broadens the employes' perspective and increases their interest in their own work.

It is creditably stated that at present there are in the United States more than 300,000 employes working under shop representation plans created to give them a voice in the conduct of the shops in which they work, and that in by far the larger number of cases considerable progress has been made in establishing the most cordial relations between management and employes.

The crux of the industrial problem includes the question—How the just share of each party to industry is to be determined and how is each to be guaranteed its right to share progressively in increasing productivity, and be held also to the corresponding obligation to see losses proportionately shared? This obligation is often overlooked. Nominal wages have increased enormously, and it is safe to assert that real wages have also augmented despite the high cost of living and the fact that in the early days of industry few workers depended entirely upon their wage but were "found" many things which must now be purchased.

Manufacturers naturally wish to see their employes receive a wage, with reasonable working hours, which will support them in comfort. This, of course, is only possible when economic conditions will permit, as wages are not and cannot be based on the cost of living. If this condition is to obtain, the employe must live in accordance with his income and responsibilities and exercise frugality and care in his expenditures. Unless this is done, the real interest of the employer and employe will not be conserved because wages would be lifted to the point of throttling the industry.

Advantages of Increased Security and Continuity of Employment.—Scientific management—which is in fact little more than getting rid of confusion and perfecting adjustments, or in other words, good management—has entered largely in recent years into the human problem in industry. As helping to avoid undue strain on the part of the worker, and waste of time and materials, it should be of benefit to all concerned. It should remove the cause of any hostility to the broadest application of scientific knowledge of the conditions of maximum labor efficiency, to the gain of all parties to production. The scientific management which dealt in the earlier stage with individual output in an engineering way must now deal with men collectively and develop that scientific breadth of imagination and application which is becoming a vital necessity for the welfare of a modern civilized community.

The psychology of labor, both in good and hard times, says Professor Commons, is fundamentally the psychology of a class of people whose life in insecure. The accident compensation law has accomplished the first little step toward giving security to the job. It has shown that the only way to establish safety and security is by making it financially profitable to do so. And so shall we make it financially profitable to business to eliminate to a large extent the wage loss due to unemployment on account of sickness, on account of changes in seasons, and on account of fluctuations in business. Labor can never accomplish this result. The only possible accomplishment of it will come when the employer arranges to cover unemployment from sickness by some adequate form of insurance, to the expense of which the employe will contribute, indemnifying the employe against loss of employment from this cause (accident is now covered by our compensation law), and to lessen unemployment on account of the fluctuation in production because of changes in seasonal demand by the proper use of stocks of finished product so as to smooth out these fluctuations and also those due to abnormal variations in business.

Increased security and continuity of employment greatly lessen the human problem, but on account of lessened labor turnover and uniformity of production they also reduce the cost of the product. Many progressive industrial organizations have gone far beyond the requirements of the accident compensation laws and the safety of the worker, incurring large expense in providing liberally for free life insurance, advantageous savings and loan opportunities, housing, service pensions and education.

Educating the Workmen.—Additional phases of helpful education might well be tried; for example, how to make repetitive work, in itself monotonous, interesting. A knowledge of the "why" of their product and the use of it and of related products of other departments has been found to materially broaden the operators' perspective. Then, too, workers can be encouraged to exercise their ingenuity in devising means to lighten and quicken their work and thereby incidentally increase their earnings. With shorter working hours there arises the question of what to do with idle time. Any one who investigates the use to which the average employe devotes his leisure undoubtedly will be convinced that such employe would be much better physically, mentally and morally if he had less idle time, for it is generally used in loafing or in amusements which consume a material part of his earnings without corresponding benefits.

Work well done and with a knowledge of progress is a source of enjoyment with many, taking the place of the recreation others find necessary to their happiness, but education of both sexes in ways in which to use leisure time profitably yet pleasantly is needed. The young should be taught thrift, for a thrifty person will not uselessly waste his leisure time. The human problem in industry cannot but be largely affected by example. H. G. Wells speaks of the disturbing influence of "the obvious devotion of a large and growing proportion of the time and energy of the owning classes to pleasure and excitement. This spectacle of amusement and adventure affects the imagination of the working man. In making labor a part of every one's life and the whole of nobody's life lies the ultimate solution of our industrial difficulties."

The human problem in industry is very complex and can never be entirely solved. To measurably improve the feeling of confidence of the employe in the employer we must always and fundamentally be absolutely honest in our dealings; not only honest in our actions but also in our thoughts and intentions. Unpleasant facts and information necessary to be told to the employes should be given them as honestly as the others, and very promptly, so as to give them as much time as possible to adjust themselves to difficult or distressing conditions.

Finally, it is not clear that at least one direction of the solution of the problem is along educational lines? First, education of ourselves, the employers to a more general understanding of the spiritual, personal, economic and physical relations involved; and second, education to encourage and aid in every proper way the general and vocational training of the employes in thrift, especially the younger boys and girls, but also the mature but still impressionable group of young men and women who are keen to learn how their position in the workaday world can be improved. Example in this effort to educate and train the employe is especially effective. Such educational effort should establish confidence and encourage co-operation. It should also be directed so as to develop individuality in each workman and woman.

Let us therefore substitute the rule of reason and intelligence for force and so endeavor to restore in America the freedom of the individual, be he employer or employe—"that freedom which enables the young man to look into the future with confidence, knowing that the only limitations to his achievements are the boundaries of his intellect and the measure of his energy."

Connections for Electrical Firing in Blasting

How Series, Parallel and Parallel-Series Connections Are Made and the Necessary Calculations, Described in a Paper Presented at the San Francisco Meeting (September, 1922) of the American Institute of Mining and Metallurgical Engineers

By N. S. GREENSFELDER.

Series Connection.—When the caps are connected in straight series, the current flows from one cap to the next and so on through all the caps. If one cap should fire an appreciable length of time before the others, the circuit is broken and the other caps will probably not fire. For this reason the series connection is the least desirable but it must be used when firing with a blasting machine because the current generated by these machines is of short duration and not sufficient to fire a group of caps connected in other ways. A current of at least 1.5 amp. should be used, regardless of the number of caps in series, to assure a sufficiently large factor of safety. The resistance of each cap used can be obtained from the manufacturer, and the required voltage figured by Ohm's law (volts = current × resistance) using 1.5 amp. for current.

To illustrate the calculations for a series connection suppose that it is desired to know what power is required to fire 25 No. 8 electric blasting caps with 6-ft. (1.8 m.) iron wires, with the source of power 1,000 ft. (305 m.) from the shot, assuming that the cap wires can be connected to one another without using connecting wire. The current for straight series connection is 1.5 amp. As the resistance of each cap is 1.343 ohms, the resistance of all the caps is $25 \times 1.343 = 33.57$ ohms. The resistance of No. 14 copper lead wire is 2.525 ohms per 1,000 ft. Lead wire resistance is $2 \times 2.525 = 5.05$ ohms. The total resistance of the circuit is $33.57 + 5.05 = 38.62$ ohms. The required voltage (by Ohm's law) is $1.5 \times 38.62 = 57.93$ volts.

In large shots connected in series, the whole circuit can be tested with an ohmmeter before firing. The theoretical resistance can be accurately figured from the known resistances of the leading wire, connecting wire and blasting caps; which should check up fairly closely with the reading of the ohmmeter. Series connections can also be tested with a galvanometer; this is not as accurate or reliable a test as that obtained with an ohmmeter, but it usually enables the blaster to detect and locate short circuits, broken wires or poor connections.

Parallel Connection.—The parallel connection is the best and should be used wherever convenient and possible. In this connection, each cap is independent of all others and one defective cap cannot affect the action of the other caps in the group. Each cap is connected across the two lead wires, and differences in resistance of the caps do not affect the result, because with a sufficiently strong current every cap detonates, no matter what its resistance may be. This connection cannot be used when firing with a blasting machine, because more current is required than the machine can furnish. Neither can the entire circuit be accurately tested with an ohmmeter or a galvanometer, as can the series connection. About 0.75 amp. per cap is a safe figure for the current required with the straight parallel connection. With a large number of caps, the amperage required is relatively high so that this arrangement can be used only with a comparatively high current supply, but the straight parallel connection reduces the probability of misfires to the minimum.

The voltage required is figured by Ohm's law as in the series connection; the following problem illustrates the method of making the calculations: What power is required to fire 50 No. 8 electric blasting caps with 6-ft. copper wires, when 2,000 ft. of No. 14 copper leading wire is required from the shot to the source of power and No. 20 copper line wire is used along the shot, with the holes spaced 4 ft. apart in a single line, as in blasting a ditch. The current required is 0.75 × 50 = 37.5 amp. The resistance of one cap is 1.343 ohms; therefore, the resistance of the 50 caps in parallel is 1.343/50 = 0.027 ohm, which is practically negligible. The resistance of 2,000 ft. of No. 14 wire used for leads is 5.05 ohms. With the 50 caps spaced 4 ft. apart, the distance covered by the shot is 200 ft. Therefore, 2 × 200 = 400 ft. of say No. 20 copper connecting wire is necessary for connecting the shot. The current in passing through this connection diminishes from full strength at one end to practically zero at the other. Therefore, we can approximate the amount of voltage required by using one-half of the resistance of the total wire in the line, viz., of 200 ft. of No. 20 copper wire which is 0.2 × 10.15 = 2.03 ohms. The total resistance of the circuit is 0.027 + 2.03 + 5.05 = 7.1 ohms. The required voltage = 37.5 × 7.1 = 266.25; approximately 270 volts.

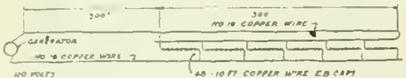

Fig. 1.—Parallel-Series Connection.

Parallel Series Connection.—The parallel series connection, shown in Fig. 1, is better than the straight series connection, because it reduces the number of caps connected in straight series, and thereby reduces the chance of the circuit being broken by a more sensitive cap firing in advance of the others. The more closely this connection can be made to approach the straight parallel the better. This is done by connecting as many groups of caps in parallel as the available current will permit. We recommend having 2 amp. per series and as many series as possible.

In the problem assumed in Fig. 1, there are 12 amp. and 110 volts at the generator. There are 48 holes to be fired approximately 5 ft. apart; in round numbers requiring about 300 ft. of connecting wire. The generator is 300 ft. from the shot so that 600 ft. of No. 16 copper leading wire is necessary, combining this with the 300 ft. along the shot makes a total of 900 ft. of copper wire. The resistance of 1,000 ft. of No. 16 copper wire is 4 ohms; the resistance of 900 ft. is 4 × 0.9 = 3.6 ohms, the resistance of the leads. The drop in voltage would equal 12 amp. × 3.6 ohms = 43 volts approximately. The voltage at the shot would be 110 volts — 43 volts = 67 volts. In order to put the 12 amp. through the shot with 67 volts, we can have a maximum resistance of 67 ÷ 12 = 5.6 ohms approximately. This means that the resistance of the 48 electric blasting caps and the wire to which they are connected shall not exceed 5.6 ohms. Each 10 ft. copper wire electric blasting cap has a resistance of 1.2 ohms. There are six series of eight caps each. As the resistance of each series is 8 × 1.2 = 9.6 ohms, the combined resistance of the caps in six series connected in parallel is 9.6 ÷ 6 = 1.6 ohms. We are allowed 5.6 so that there are 5.6 — 1.6 = 4.0 ohms left for the connecting wire. We must choose a wire 300 ft. long, the resistance of which will not exceed 4 ohms. From a table of resistances, we find the nearest to be No. 21 wire.

With this connection, it is desirable to have approximately the same resistance in each series. Consequently, approximately the same number of caps with wires of equal length should be used in each series; this number should not vary more than one cap. The lead wires should be connected so that they will cross opposite ends of the shot, as shown, otherwise the series farthest from the shot might not receive sufficient current. This system is open to the same objection as the straight series, but as there are fewer caps per series, there is less possibility of misfires. It is a simple connection to make and works successfully in practice.

Series Parallel Connection.—The series parallel connection is next best to the straight parallel connection. This system, shown in Fig II, approaches the parallel connection, in having each cap connected to the line separately, independently of other caps. The different groups of caps are connected in series in the firing circuit. A current of 1.5 amp. for each cap in a group is recommended; that is to say, if eight is the maximum number of caps in any group the minimum current to figure on is 12 amperes.

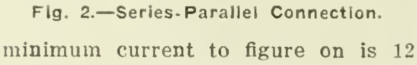

Fig. 2.—Series-Parallel Connection.

In a problem similar to that just given, the lead wires should be connected to opposite ends of the shot as in the parallel, and always to the shortest leg. Again, 900 ft. of lead wire is required, and the drop in the line is 43 volts, leaving 67 volts at the shot, with a current of 12 amp. The maximum resistance allowable in the caps and connecting wire is 67 ÷ 12 = 5.6 ohms. With a current of 12 amp. available and 1.5 amp. figured for each cap in parallel, there can be 12 ÷ 1.5 = 8 caps in parallel in one group; for the 48 caps, six groups are required. The resistance of one cap with 10 ft. of copper wires is 1.2 ohms; the resistance of each group therefore is 1.2 ÷ 8 = 0.15 ohm. For the six groups, the resistance is 6 × 0.15 = 0.9 ohm. This leaves 5.6 — 0.9 = 4.7 ohms for the wires along the shot to which the cap wires are attached. We have assumed that two wires each 300 ft. long are used. For all practical purposes, we can figure on one length of line wire, viz., 300 ft., with a resistance of not over 4.7 ohms. From a table, No. 21 copper wire is found to be the nearest to this.

We have determined, therefore, that with 110 volts and 12 amp. at the source of power, not over 900 ft. of No. 16 or larger copper leading wire, and not over two lengths of 300 ft. each of No. 21 or larger, connecting wire along the shot, six groups of caps in series, each group consisting of eight caps in parallel, can be fired. There is large enough a factor of safety in these calculations to permit firing a few more caps, but it would be better not to do so. It is advisable to have the same numbers of caps in each series, but if necessary the number may be varied by not more than one. Always have the smallest number of groups in series and the greatest number of caps per group in parallel that can be arranged; in other words, make it as near a straight parallel connection as can be done with the current available.

Flood Discharge Formulae*

By THOMAS WALKER,

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There are numerous flood discharge formulae extant, in fact, they are so numerous and vary so in results that it seems impossible to reconcile the widely divergent results which are obtained by applying the numerous formulae to any particular drainage basin.

After considerable study of the question of flood discharge, the writer is convinced that any formula at the best can be but an approximation. Nevertheless, it is believed that by careful analysis and study of a drainage basin in question, fair results can be obtained by a flood discharge formula. It is thought, however, that a formula with a variable coefficient is the only kind practicable to give satisfactory results, in view of the widely divergent climatic and topographic conditions. Most formulae seem to have been devised to fit a limited locality, and may, if applied to an entirely different region, give erroneous results.

With the above in view, the writer has endeavored to frame a formula expressed by the equation $D = \frac{C\,R\,M}{G\ 5\text{-}6}$ in which the notation is as follows:

D = Discharge in cubic feet per second.

C = Variable coefficient.

R = Mean, or normal, annual rainfall in inches over the entire drainage basin.

M = Area of basin in square miles.

G = Straight line distance in miles

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*From the August Bulletin of the American Railway Engineering Association.

from point of discharge to center of gravity of basin.

The factor R can no doubt be criticized, as it can be well argued that the flood discharge does not always vary with the value R. Nevertheless an investigation will show that there is a decided relation between D and R and the introduction of the latter factor greatly narrows the variation of C. A value of R for a smaller unit of time would be preferable, say the normal maximum monthly rainfall, or even shorter period. The annual averages are, however, more readily obtained and it is thought gives fairly good results. The rainfall of a basin in question should, of course, be carefully studied and any peculiarities should be taken care of by the variable C. This is particularly true of arid, semi-arid, and mountainous country, such as Southern California, Arizona and New Mexico, where the coefficient C shows a wide variation.

The formula is framed with the view of ascertaining the greatest flood discharge that may be reasonably expected over a long period of years, or about once or twice in a generation. With this in view the value of C usually varies between 4 and 30, being a maximum for drainage basins having impervious surfaces, little storage, steep slopes, little vegetation, direct alignment of waterways, etc., and minimum for pervious surfaces, much storage, flat area, much vegetation, and waterways with irregular and meandering alignment.

The majority of values of C range between 8 to 20 for average conditions, a general average being about 12.

It should not be understood from the above that 30 is the extreme value of C, for in some cases very much greater values have been obtained, principally in the arid and semi-arid and mountainous places above mentioned. At some places, in the Southern California floods of 1916, values of C ranging from 40 to 160 were obtained, also in northern New Mexico values of about 70 or more were secured. Such values as these are, however, exceptional and extraordinary and seem confined to particular districts.

Undoubtedly the best method of obtaining the value C to be used in any particular case would be to select places in the same vicinity, subject to the same climatic conditions, where values of D are known and solve the formula for C. In adopting this method care should be used to select places as near as possible to one in question, as near the same area and having the same climati conditions.

By using this method and making due allowance for topography, etc., a reasonably accurate figure for the flood discharge can be secured. In fact, by this method of comparison, values of C may be secured which will give maximum flood to be reasonably expected, as well as the year to year floods, or average annual floods, or any conditions of discharge desired.

The U. S. Geological Survey maintains gaging stations in all parts of the country, and publishes annual water supply bulletins giving areas, stream discharges, etc. These bulletins, or other sources of information, can be used for ascertaining the value of C. It should be noted, however, that unless the gaging station has ben maintained for a long period of years, or unless high water marks from earlier floods have been secured, the bulletins may not give the maximum flood that can be reasonably expected. There is, of course, always the possibility that a flood may occur, which will exceed all previous records. This is especially true of small drainage basins.

It should also be noted that in the case of the smaller drainage basins, the water supply bulletins do not always give the crest flood, as the gages are usually read only once or twice each day, and the crest of flood may have occurred between the readings. This point is not of great importance in large waterways, as the crest may be of long duration, or slight variation, but in small waterways, where crest is of short duration, it is quite important. In general, statistics for flood discharge of very small waterways are meager and uncertain. The formula, though, is intended to give results for any area from a fraction of a square mile to over a million square miles, and has been tested over such a range. The results for extremely small basins, say less than 5 square miles, are probably not as reliable as those of large areas.

It should not be assumed, from the form of the formula, that it is based on the theory that the discharge varies directly as the area. As a matter of fact, it is based upon the assumption that, other things being equal, D varies as $M^{0.583}$. This power of M was secured by platting on logarithmic paper, a great number of values of D, secured from all parts of the country and then attempting to define an average line. This was, however, difficult, as values of D show such a very great range. Nevertheless, it is believed after much study and experiment that the power 0.583 is reasonably accurate for average conditions.

The factor G is introduced in order to make allowance for the shape of the basin. As far as known, this factor appears in no other flood discharge formula. A number of formulae take the length of the basin into consideration. The factor G. provides for the shape of the basin as well as the length, and both are important, and considerably affect the instantaneous discharge.

After considerable study, it is concluded that the expression $\frac{M^{0.417}}{G^{0.833}}$ satisfactorily provides for the shape of the basin, other things being equal. Introducing this factor into the equation $D = CRM^{0.583}$ reduces it to the final for $D = \frac{CRM}{G\ 5/6}$. The values have been arbitrarily varied, to a very slight degree in order to simplify the formula and reduce it to its final form. It is entirely consistent to do this, in view of the very wide range of discharges, and as the very small variations are practically corrected in the ascertained values of C.

In conclusion it may be remarked that the question of flood discharge is one of much uncertainty and varies very greatly and it is only by intelligent study and analysis that reliable results can be obtained by any flood discharge formula.

Annual Meeting of Iowa Engineering Society.—The annual meeting of the Iowa Engineering Society will be held at Des Moines, Iowa, January 23, 24, 25, and 26.

Railway Capitalization in Various Countries

The capitalization per mile of the American railroads is lower than that of the more important countries of the world, with very few exceptions, according to a review of railway capitalization made recently by executives of the railroads. The survey was undertaken so that exact figures on comparative railway capitalization would be available for purposes of refusing the frequently propounded thesis by labor unions that American railways are greatly overcapitalized.

The capitalization per mile of the railways of the United States in 1920 was shown at $68,787; that of Canada was $65,714; Germany's was $279,427, and the United Kingdom's was $274,605. The capital per mile of France's five large private companies excluding the State and western roads—was $186,394 in 1920; that of Denmark, $80,504; Switzerland, $141,244; China, $54,580; India, $54,913; Japan, $111,156, and the Union of South Africa, $50,819.

In part, the reason for a lower capital per mile in the United States, is that railway construction often preceded the founding of cities, the growth of population, and the resulting increased value of land. This is only a partial explanation, however, it was said, for in large measure, railway construction in the United States was described as being carried on so efficiently and on so large a scale as to keep unit costs very low.

In Canada and Australia somewhat similar conditions have applied as in the United States, it was said. Developments in Australia and most sections of Canada are new, compared with the United States, and consequently the capital costs tend to be lower, it was added. In France, Germany, England, Japan and Switzerland, however, cities sprang up originally without relation to future railway development, with the result that railway construction has been most expensive in those countries. The location of cities already in existence in each of these countries naturally controlled the location of the railways, the officials point out, which inevitably led to less economical and often roundabout construction.

In the following table—prepared by tho Bureau of Railway Economics—the total railway capital and capital per mile of the railways of the principal countries of the world is shown:

Country.	Capital.	Capital per mile.
America:		
Canada	$ 2,588,071,016	$ 65,714
United States	*16,993,930,263	68,787
Europe:		
Denmark	115,844,757	80,504
France	‡3,856,214,779	‡186,394
Germany	9,664,942,000	279,427
Norway	110,464,309	54,095
Sweden	405,093,253	43,845
Switzerland	459,130,072	141,244
United Kingdom	6,517,474,647	274,605
Asia:		
†China	203,560,568	54,580
India	2,033,356,393	54,913
†Japan	689,423,599	111,156
†Siam	22,471,448	38,028
Africa:		
Union of S. Africa	485,783,208	50,819
Australia:		
†New South Wales	386,005,510	76,964
New Zealand	181,205,364	60,043
†Queensland	191,910,929	35,757
†South Australia	94,825,368	40,849
Western Australia	87,900,446	24,839
†Victoria	280,044,383	66,837

*Net capitalization.

†State railways.

‡Statistics for the five private companies only; does not include the State and Western railways.

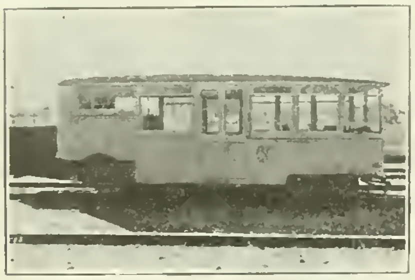
The lower capital costs of the railways of some of the Asiatic countries, such as China, India and Siam, and also South Africa, were attributed to the low labor costs of those countries. The capital costs of Germany and the United Kingdom was shown to be, comparatively, more than four times that of the United States; France's was three times as great; Switzerland's more than twice as great; Japan's nearly twice as great.

The "net capitalization" of the American railroads, shown as $16,933,930,263, was defined as the total amount of the par value of American railway securities, less the par value of those securities still held in the treasuries of the various companies and not issued, and the securities of one road owned by another. In other words it may be defined as the aggregate amount of railway securities outstanding in the hands of the American public.

The valuation of the railroad properties of this country, according to the Interstate Commerce Commission, and arrived at tentatively for rate-making purposes, was $18,900,000,000 as of September, 1920, since which date about $500,000,000 has been added in capital betterments and improvements.

New Gasoline Driven Rail Car

The Hetch-Hetchy R. R., operated by the city of San Francisco, Calif., has recently placed in service a gasoline-driven rail car having a number of new features. The car was invented and patented by A. R. Meister and was built by The A. Meister Sons Co. of Sacramento, Calif., at a nominal cost of $8,500. It seats 30 passengers and is built for either narrow or broad gage railroads. On the Hetch-Hetchy R. R., it is stated, it negotiates a 5 per cent grade 12 miles long with numerous 30° curves at a speed of 27 miles per hour.



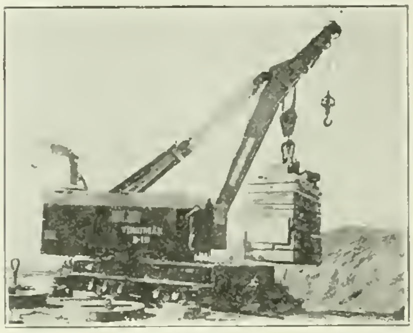
Gasoline Driven Rail Car of Hetch-Hetchy R. R.

By placing the motor rearwardly of the driving wheels the designers have eliminated all revolving parts in front of rear axle, thereby permitting a very low hung car and eliminating all motor noises and smoke or gasoline odors. This also has enabled an increase of passenger seating capacity without lengthening the wheel base of car. The designers also have eliminated vibration and increased the traction by suspending the motor on coil springs direct over the rear axle on one end of a sub-frame to the main frame.

The sub-frame makes one-half of a complete truck as it has a swivel bolster built in the main frame so that it will turn at curves, thus eliminating flange wear and relieving side thrust. The car rides equally as well in rear seats as in the center of car. The car complete weighs but 10,400 lb. and is stated to make 8 miles per gallon of gasoline.

A 200-Ton Capacity Railroad Crane

The Virginian Ry. has recently placed in service a railroad wreck crane, said to be the largest ever built. The largest previous crane of this type is stated to have a maximum capacity of 320,000 lb. with all outriggers. The Virginian Ry. crane, which was designed and built complete in the Industrial Works, Bay City, Mich., has a capacity on the main hoist of 400,000 lb. at 17 ft. 6 in. radius with all outriggers, 200,000 lb. at 17 ft. 6 in. radius with end outriggers only and 85,000 lb. at 17 ft. 6 in. radius without outriggers. The capacities on the auxiliary hoist are 90,000 lb. at 24 ft. to 30 ft. radius with end outriggers only and 60,000 lb. at 24 ft. radius without outriggers. The crane is mounted on special six wheel trucks and has a maximum axle load in running order of 64,000 lb. The car has a total wheel base of 26 ft. 2 in. and is 34 ft. long. The crane is 15 ft. 9 in. high at is highest point and 10 ft. 6 in. wide at its widest. The engines are 12 in. x 12 in. and steam is provided by a 65 in.—160 lb. A. S. M. E. boiler. A Westinghouse air pump is provided with clasp brakes on each of the 12 wheels. The brakes may be operated by the engineer on the crane or by the engineer of the locomotive which may be hauling the crane in a train. All clutches are operated by air. The crane in running order weighs 356,500 lb. The main design problem met with in building this crane was to keep within railroad clearances and the maximum allowable axle load—on account of bridges —of 65,000 lb. and still to obtain the 200-ton capacity required by the excessively heavy rolling stock.



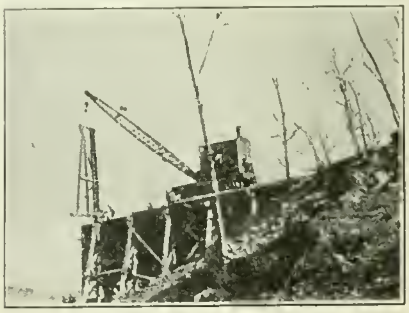
New Railroad Wreck Crane of Virginia Ry.

Examination for Aeronautical Engineer.—The U. S. Civil Service Commission has announced the following open competitive examination: Assistant aeronautical engineer, $2,000 to $2,400 a year; associate aeronautical engineer, $2,500 to $2,880 a year; aeronautical engineer, $3,000 to $3,600 a year. Receipt of applications will close on Jan. 30. The examinations are to fill vacancies in the Federal classified civil service throughout the United States. The duties of appointees will be to assist in, conduct, or supervise experimental and research tests, perform calculations, design aircraft, accessories, and equipment, carry out studies of aeronautical problems, and perform such specific work as designing and detailing structural parts of aircraft and their fittings, writing specifications, making weight, stability, and strength calculations, checking plans and specifications and handling technical correspondence.

Erecting Trestle Bents with Crane

A locomotive crane was used in erecting framed trestle bents at the Mitchell Drain at Verbena, Ala. The accompanying illustration reproduced from Successful Methods shows the particular feature. The bents were framed on the bank, and by using the crane they were quickly swung into place at a cost of about 75 per cent of the usual cost and at a great saving of time.

The Mitchell Dam, which is being built for the Alabama Power Co. by the Dixie Construction Co. of Birmingham, Ala., is on the Coosa River about 60 miles south of Birmingham. It is one of the many hydro-electric power developments now being made in the South and will furnish power for a considerable section of the country.



Crane Erecting Framed Trestle Bent.

On the actual construction work electrical equipment is used almost exclusively. Bulk cement also is used.

Device for Feeding Boiler Compound Into Steam Shovel Boilers.

A device for feeding boiler compound into steam shovel boilers, used by the Kelly Island Lime & Transport Co., Clay Center, Ohio, is described by T. P. Ward, General Foreman, in the December Excavating Engineer, from which we quote the following:

"We found that by putting compound in the water tanks of our shovels that the great portion of it settled in the bottom and consequently was not giving good service.

"About six months ago we placed a container between the injector and check valve on the boiler feed line. As soon as the injector is in operation the value at the bottom of the container is opened and the contents carried into the boiler.

"These containers can be made to hold any required amount for a 24-hour period. The one which we used is made of a piece of 5-inch pipe 10-ins. long with top and bottom heads welded. The top has a 1-in. plug for filling, and the bottom has same opening as the injector line."

Draftsmen for Government Service. —The U. S. Civil Service Commission has announced the following open competitive examination: Junior mechanical draftsman, $1,400 to $1,800 a year; assistant mechanical draftsman, $1,800 to $2,400 a year; associate mechanical draftsman, $2,400 to $3,000 a year. To fill positions in the Ordnance Depart-

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Roads and Streets—1st Wednesday
(a) Roads
(b) Quarries and Pits
(c) Streets
(d) Street cleaning

Waterworks and Hydraulics—2nd Wednesday
(a) Water Works
(b) Irrigation and Drainage
(c) Sewers and Sanitation
(d) Waterways

Railways—3rd Wednesday
(a) Steam Railway Construction and Maintenance
(b) Electric Railway Construction and Maintenance
(c) Quarries and Pits for Ballast and Concrete

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures

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Current Prices Published in Engineering and Contracting

With this issue we begin the publication of current prices paid by contractors for important building materials in some 29 cities scattered throughout the United States. These prices are secured monthly by one of the most painstaking and reliable of government agencies—the Bureau of the Census—and are released for publication by the Division of Building and Housing, Bureau of Standards, U. S. Department of Commerce. In addition to these we quote from The Iron Age a few of the more important iron and steel prices, and freight rates from Pittsburgh to various cities.

Each Buildings issue of Engineering and Contracting will contain these data, and it is our purpose to improve and enlarge this section of our paper from time to time.

We believe that the data will prove of great convenience to our readers as a guide to construction material price conditions throughout the country, and in the preparation of the quick estimates which both engineers and contractors are frequently called upon to make, as the tables cover the most used materials at numerous representative and important points. For the preparation of detailed estimates on which bids are to be based, they are quite obviously inadequate. In fact we know of no source other than actual quotations which can be used satisfactorily for this latter purpose; but for other purposes the data here given will save many of the valuable minutes or even hours, which are so often required in getting prices or quotations from scattered sources.

Increasing Opportunities for Building Contractors in the Growth of Home Ownership

The small contractor in particular will note with interest the substantial increase in the proportion of homes owned to homes rented which is revealed by figures from the Bureau of Census statistics; for the tendency there shown indicates steadily growing opportunities in his special field. The data for 68 cities of more than 100,000 population in 1920 show 55 cities as having increases in the percentage of homes owned since 1900 and only 13 with decreases. Still more significant is the fact that while the decreases of percentage were in most instances small, the increases were often striking.

The greatest percentage increase was in the case of Birmingham, Ala., where the percentage of homes owned rose from 13.8 to 28.1 in the 20-year period. Other large increases during the same time were: Omaha, Neb., 27.7 to 48.4 per cent; Philadelphia, 22.1 to 39.5 per cent; Camden, N. J., 55.7 to 40.5 per cent; Baltimore, Md., 27.9 to 46.3 per cent; St. Paul, Minn., 29.9 to 46.1 per cent; Seattle, Wash., 31.6 to 46.3 per cent.

The principal reductions were: Los Angeles, Calif., 44.1 to 34.7 per cent; Akron, O., 53.7 to 44.7 per cent; Cambridge, Mass., 21.2 to 17.6 per cent; Springfield, Mass., 33.3 to 27.9 per cent.

During the 10 years from 1910 to 1920, twenty of the 68 cities suffered reductions in the percentage of homes owned, and 3 showed no change. The largest of the reductions was in the case of Los Angeles, where the change was from 44.7 to 34.7 per cent. The next largest was at Spokane, Wash., and was from 51.3 to 44.6. The greatest increase during this period was shown by Philadelphia, with 26.6 per cent in 1910 and 39.5 in 1920. Camden, just across the river, was a good second in this race, while Wilmington, Del., was third with a rise from 30.4 to 38.3 per cent.

New York City had the lowest rate of home ownership in 1920, the percentage being only 12.7. In 1910 it was 11.7 and in 1900, 12.1 per cent. Cambridge was second lowest in 1920. Des Moines, Ia., stands highest in 1920, with 51.1 per cent of its homes owned. In 1910 its percentage was 45.6, and in 1900, 38.5. The figures for Chicago were 1920, 27.0 per cent; 1910, 26.2; 1900, 25.1.

Considering the country by major sections, the Southeast shows the most marked tendency toward home ownership.

Meeting of American Concrete Institute.—The 19th annual convention of the American Concrete Institute will be held at the Hotel Sinton, Cinnati, O. Jan. 22-25. Harvey Whipple, Detroit, Mich., Secretary.

A Forward Step in Civic Development

The specifications for the regional plan of Los Angeles County printed on another page of this issue are a masterpiece of their kind. They admirably provide the fundamentals of a scheme which, if carried out, will work to the very great advantage of every community within the district. They do not attempt to set forth details, of which there will be an infinite number, and which will require a long time and a great amount of labor in the working out.

The specifications provide the framework on which the details must be hung. Without such a framework no true regional plan could exist; and it is in the provision of this foundation without either serious omissions or an extension into the field of details which are better left for future treatment by other agencies that this plan excels.

Those in whose minds "city beautiful" and "city planning" are still synonyms will find in the Los Angeles County plan, a correction of their misconception and an excellent illustration of the manner in which wise planning, while including civic beauty within its scope is concerned first with the economic welfare of the community and its "development along practical lines." This is at it should be, for necessary as beauty is to man, his physical welfare takes precedence. A scheme of embellishment is not a city plan; nor is it even an element of first rate importance. An orderly and efficient arrangement of streets, with abutting property developed to appropriate and non-conflicting uses affords the prime element of civic beauty, to which ornamental features form an appropriate adjunct.

The Los Angeles County plan is not one involving wholesale consolidations of town and city governments. It is designed especially to leave to each community the corporate independence which it has found desirable in the past, and which in many cases it will properly wish to retain permanently. What the plan does do is to provide a central organization through which the numerous communities may co-operate in the establishment of main line thoroughfares to supersede present routes over streets and roads often both inadequate and essentially unrelated; in the provision of trunk sewers and sewage disposal works with resultant economies in cost and reductions and elimination of nuisances; and in every other way in which there is an advantage in co-operative effort in the establishment and operation of physical properties.

Forest vs. Agriculture

In a report to the Conservation Commission of the State of Indiana, Mr. Charles C. Deam, forester for the commission, gives figures showing that if the rate of clearing from the year 1917 to date is continued, Indiana will be without forests within the next fifteen years. It is pleasing to note that while Mr. Deam emphasizes the seriousness of the situation and the importance of finding a remedy, he treats the subject systematically and without the excitement so frequently shown by editors and others in the popular press.

As against the over-zealous forestry enthusiast, we have the agricultural enthusiast who wants to see every available acre of land put under cultivation, and it is to such that Mr. Deam's paper can be of the most value if they will heed it.

Mr. Deam's observations and deductions given in the report are quite simple. He shows that in 1920 the state's woodland area was slightly less than 1,400,000 acres, or a little more than 6 per cent of the total land area of the state. There are large areas of hill land which are good producers of timber but which are not suited to any form of agriculture. Nevertheless, mistaken efforts are continually made to clear and cultivate them. During the war some such land was cleared and crops grown under conditions which could not possibly produce a profit or be of economic advantage to the community in time of peace. Not only is the labor and expense of such unprofitable cultivation an economic loss to the community, but lands cleared and then abandoned as a rule grow up to sassafras, persimmon, greenbrier, etc., which interfere for years with the start of any desirable forest growth.

In addition to the direct and obvious value of the wood and timber grown, Mr. Deam cities a series of indirect values, some of them well known, as follows: Wind protection to buildings, orchards and crops; protection of live stock from piercing wind with a consequent saving in the feed necessary to maintain animal heat; purification of the air; prevention of rainfall from quick runoff and consequent severe erosion; provision of a home for economic birds such as weed seed eaters and the insectivorous varieties; and the encouragement of more wild game and fur bearing animals.

Even now, Mr. Deam says, Indiana has much cleared land which is not in use, statistics for 1919 showing 12,748,000 acres in crops, and fallow land totalling 1,079,000 acres, or about 8 per cent of the total cleared. In the hill counties, the percentage of idle land was much bigger than the average, one county showing as much as 47 per cent of its cleared land fallow. In a first class agricultural county, on the other hand, less than ½ of 1 per cent was uncultivated. Mr. Deam estimates that Indiana has at least 2,000,000 acres that should be devoted to forests.

Fire Test of Building By U. S. Bureau of Standards

Some experimental work has been undertaken by the U. S. Bureau of Standards in connection with investigations of the fire-resistive properties of building materials, to determine the actual fire exposures to which building constructions may be subjected as used to house various occupancies. In furnace fire tests of such constructions, they are subjected to fire exposure the intensity of which is determined according to a standard time-temperature relation, the furnace temperature being near 927° C. (1,700° F.) at the end of the first hour, 1,010° C. (1,850° F.) at 2 hours, and following this a uniform rise to a maximum of 1,260° C. (2,300° F.) at 8 hours if the test is continued to this point. This intensity has been thought to represent a moderately severe building fire, the duration of which will depend on the building construction and building contents, the latter being determined in a general way by the occupancy. Fires of long duration and high intensity are produced by such occupancies as heavy manufacturing, merchandising, and storage, with office and residence occupancies at the other end of the scale, as giving the least duration and intensity.

In a test just completed at the Bureau of Standards, a 1-story brick and concrete building, 16x30 ft., was fitted up with discard furniture to represent a fairly severe office occupancy. A wooden top floor on sleepers in cinder fill was placed on the concrete base floor. The window openings were provided with pivoted incombustible shutters for regulation of air supply to give maximum fire conditions. At first an attempt was made to simulate an exposure fire. In such a case the fire enters in considerable volume from the adjoining rooms or buildings and to approximate this condition an amount of readily combustible material was ignited at one point near the end of the room. It was hoped that approximately simultaneous ignition would be secured in all parts of the building, but the attempt failed because of the blanketing effects of the gases which had to be retained in order to raise the temperature to the ignition point. The fire started at one end of the building and progressed to the other in about 15 minutes. Measurements made at about 40 points gave temperatures in excess of 400° C. (952° F.) for a little over one hour, the maximum recorded being 1,089° C. (1,992° F.). The average maximums for all levels for three sections of the building taken in the direction of travel of the fire were about 850° C. (1,562°F.), 940° (1,724° F.), and 950° C. (1,742° F.), respectively. This corresponds to an average exposure a little more severe than the first hour of a standard test fire. Some difference in temperature obtained between the upper and lower levels, although this was not large. Everything of combustible nature, including the contents of metal filing cases, was destroyed except portions of the sleepers in the cinder floor fill. The contents of an insulated steel safe of a type recommended for use in office buildings of fire-resistive construction were fully preserved, the temperatures within the safe corresponding to those obtaining after a one-hour exposure in a test furnace.

It is apparent, states a Technical News Bulletin of the Bureau of Standards, that to be conclusive further experiments will be necessary, particularly to determine the effects of larger room dimensions on intensity and duration. Efforts are also being made to obtain an estimate of intensities of fires in buildings by examination of fire ruins. An inspection made of the Burlington Bldg. (Chicago, Ill.) after the fire of March 15, 1922, indicated that maximum temperatures between 950 and 1,050° C. (1,742 to 1,922° F.) obtained generally over the burnt portion to judge by fused metals, the melting points of which were later ascertained, and at a few locations the temperatures exceeded these averages by about 100° C.

Standardization of Structural Steel Practice

Editorial in The Canadian Engineer.

Far reaching results are likely to follow from the activities of the American Institute of Steel Construction which held its first annual meeting recently in Pittsburg. This organization, which includes at the present time 113 fabricating shops in America, has its avowed object the popularization of the use of structural steel. To this end it seeks to bring about greater uniformity of practice with respect to the proportioning of steel structures, which incidentally means that working stresses will probably be increased in many instances. For some time there has been a tendency among designers of structural steel work to calculate stresses in such structures more carefully than heretofore and to allow working stresses up to perhaps two-thirds or three-fourths of the yield point. So long as the calculated stresses are not exceeded, and so long as the material is uniform and reliable in character, such a practice is justified and economically sound.

Another reform to which the American Institute of Steel Construction has addressed itself is the reduction of the number of rolled sections used in the industry, with a view to avoiding the enormous industrial waste which is now perpetrated through rolling many unnecessary sections. Having agreed upon certain standard sections the institute will prepare design tables for these sections, based upon the new working stresses, and an effort will be made to have such stresses and such tables adopted uniformly by the users of structural steel.

The upshot of the whole matter will be a distinctly higher grade of engineering practice so far as steel structures are concerned. Unfortunately, there have been in the past many structurs designed in a hit-and-miss manner, the errors and ommissions being covered by a scandalous factor of safety. If engineers are not able to utilize the material at their disposal to a greater extent than one-half its elastic limit, or one-quarter of its ultimate strength, they are not fully discharging their duty to the public. There is no reason why a skilful designer who has appraised all probable contingencies should not obtain a better service from the material he employs than has heretofore been the case in most structural designing. Perhaps the worst offenders on the ground of wastefulness are the framers of city building codes. These instead of representing the highest stage of structural design achieved to date, are in almost every instance many years behind the times. If the American Institute of Steel Construction brings about a general revision of building codes so far as steel work is concerned, it will have done a real service to the engineering profession and to the public.

Steel Output for 1922

Editorial in The Iron Age.

Estimates made two months ago of the probable steel output of the country in 1922 need some revision upward in view of the high rate of production maintained in November and the indicated rate for December, winter blockades before January being rare. There is a probability, in view of an 80 per cent ingot production through half of November, and the high rate that is looked for this month, at least up to the holidays, that the year's steel ingot output will be not far short of 33,000,000 tons, or more than 63 per cent of capacity, assuming the latter to be 52,000,000 tons. With 19,224,000 tons of ingots 1921 was rated a 37 per cent year. Thus 1922 promises to be about 70 per cent better in point of tonnage.

While the Steel Corporation has been credited with about 45 per cent of the country's steel capacity, it actually produced about 55 per cent of the total in 1921, entering that year with a good order book, while the independent companies then had little business ahead and were curtailing production sharply. In 1922 the Steel Corporation's output is likely to be less than 50 per cent of the total, probably but little more than 48, estimating that it reaches 16,000,000 tons out of a probable total of 33,000,000 tons.

Engineers and Originality

Editorial in The Canadian Engineer.

Of the many designs and projects developed by engineers, the number exhibiting real originality and inventive genius is surprisingly small. As in other professions and callings, the tendency of the average practitioner is to pursue paths that have been already explored and shown to be safe and practicable. An attitude frequently assumed by engineers is that they are not justified in conducting hazardous experiments with their client's money and that the particular situation in hand demands a procedure that will safeguard the employer against any possibility of loss.

Commendable though this attitude may be, one must not lose sight of the fact that the engineer who refuses to utilize to the full the possibilities of the material and of the situation for economies of construction and operation is culpable of neglect in the interests of his client. While it is not a serious matter to cause the useless expenditure of some thousands of dollars as to endanger the work and render the client liable to serious loss, there is no doubt that that engineer is blameworthy who does not rise to the economic situation and who does not exercise to the fullest the traditional qualities of the engineer as one who can do with a dollar what any bungler could do with two. The really great engineers of the past have not rested upon the laurels of the profession already gained but have boldly launched out on many occasions into comparatively unknown fields, trusting only their own powers of keen analysis and sound judgment. In all this, however, the client took his proper share of the risk involved and was in no sense misled as to the nature of the pioneering of his expert adviser.

For the disposition to copy and to proceed only on thoroughly tried-out lines, the modern tendency to standardize is, probably more than anything else, responsible. Junior engineers, in particular, when called upon to mature a design are disposed to move safely within the confines of a generally accepted specification. Backed by the authority of national or international committees—the framers of standard specifications—the designer feels that he cannot go far wrong, and that his chief concern is to be sure of his arithmetic. The progress that would have been made by Monier, Considere, Hennebique or Melan in the development of reinforced concrete can well be imagined had they persisted in following merely what had been done by previous workers in this field. However much the profession is indebted to standardized specifications for excellence of engineering works, there doubtless has resulted much stifling of originality from enforced conformity to established rules. Most outstanding developments in design are brought about by engineers who are forced to conform to no specification except that dictated by their own good judgment.

It is to be regretted that comparatively few engineers possess the habits of the student. Once having satisfied himself that a particular method works acceptably many an engineer is content to follow it for the rest of his professional days. There is in this little of the spirit that characterized the great pioneers in engineering such as Smeaton, Watt and the Stephensons. When investigation is undertaken by engineers it is too frequently directed narrowly toward some highly specific and special end. Through such a procedure the great value of occasional by-product discoveries is lost. There is a view held by some who are concerned with engineering research that those who possess the investigating habits of the pure scientist are superior in research to those trained in highly practical pursuits. Many valuable discoveries have been made by investigators who were merely studying an interesting field without immediate promise of the development of anything practical. We would do well in engineering research to pay regard to the philosophical habit of mind of the great pioneers in engineering science.

Results of Compression Tests of Structural Steel Angles

Compression tests of 170 standard rolled structural steel angles were made at the Pittsburgh laboratory of the U. S. Bureau of Standards during the spring of 1917. The specimens tested were all furnished by the tower department of the American Bridge Co., which co-operated in planning the investigation and in carrying out the tests. As the angles were intended for legs and lattice members in electrical transmission tower construction, the greater number were tested with bolted ends, the bolting imitating the riveting used in the construction of the towers. For comparison a number of angles were also tested with flat ends. The results of the tests are given in Technologic Paper No. 218, issued recently by the U. S. Bureau of Standards. Copies can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 ct. each.

Kansas City Architectural Club to Award Prizes.—The Architectural League of Kansas City, as a step toward encouraging better architectural design in Greater Kansas City is to award annually a medal and a bronze tablet for the best example of architecture created during the year. The architect who has made the best contribution will be voted a medal. The owner or client for whom the work was created will receive a bronze tablet.

Effect of Obsolescence on Useful Life of Office Buildings

To determine the effect of age on the income and expenses of office buildings reports were obtained from 155 buildings by Mr. Earle Schultz, president of the National Association of Building Owners and Managers. Some interesting conclusion from the data thus obtained are given by Mr. Schultz in a report in Buildings and Building Management, from which we quote as follows:

Two Periods in Life of Office Buildings.—It will be seen from chart I that the life of an office building may be divided into two periods.

Period 1 extends from the erection of the building to about the 28th year. During this period the gross income is nearly constant. The expenses, however, rise continuously with a corresponding falling off in the net return. This period represents the useful and profitable life of an office building, during which it is earning an adequate return on the investment. During most of this period, the buildings are able to maintain themselves as first-class buildings housing the best grade of tenants.

Period 2 extends from the 28th year to the end of the building's life. During this period the gross income of the building falls very rapidly as also do its operating expenses, while the net income continues to decline at a somewhat faster rate than during the first period. At the beginning of this period the building finds that through the action of obsolescence in any one or more of its several forms it is losing its better class of tenants and that it is impossible for it to maintain its income at its previous level. Because of this falling off in income, it must necessarily reduce its operating expenses in proportion by giving a cheaper grade of service, thus becoming a second grade building. In spite of all that can be done to reduce operating costs, the ever-increasing extent of repairs and replacements necessary in an old building serve to increase expenses, with the result that if the building continues in existence it soon becomes a non-producer and is very often operated at a loss.

Period 2 necessarily ends with the life of the building, which occurs when obsolescence has progressed so far that the building is torn down to be replaced by a new structure. Many illustrations may be cited of buildings thus torn down and replaced at ages varying from 15 to 40 years. Because of the fact that when a building has arrived at the second period of its life and it is only a question of time when it will have to be torn down, its investment value declines very rapidly and is very often extinguished entirely. That is, whereas if a building is sold during the first period of its life, it will bring a price somewhere near its cost; if it is sold in the second period of its life, it will bring a very much smaller price, and very often will not be considered as adding any value whatever to the land on which it stands. As a consequence, while a building in the second period of its life may for a time under favorable conditions continue to be operated at a small margin of profit, obsolescence will have largely or wholly destroyed its sale value.

Rates of Values of Land and Building.—The solid line in Chart II represents the actual 5-year averages, and the dotted line a theoretical curve drawn through these averages. From these curves it will be seen that during the early years of its life, the value of the average building is equal to the value of the land on which it stands. This ratio, however, increases more and more rapidly until at the age of 50 years the value of the land has become six times the value of the building. In other words, if a lot now valued at $100,000, for instance, requires as an adequate improvement a building costing $100,000 or more, then after a period of 50 years when the value of this lot has become approximately $500,000, any improvement thereon to be adequate must have a value of $500,000.

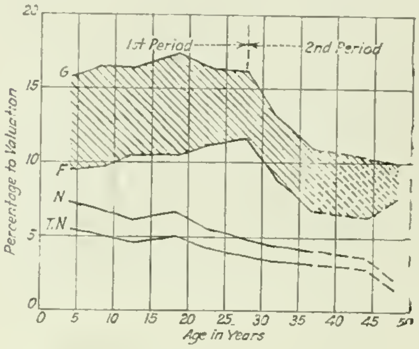

Chart I.

A study of the present ratio between land and building for buildings of different ages will indicate the effect which the growth of the business district of a city has in rendering buildings inadequate improvements of the land. This has been done by taking the ratio between land and building for all the buildings reporting, and grouping them by ages to obtain five-year averages as previously explained. The averages thus obtained are indicated on Chart II. On this chart the two curves marked "AA" represent the increasing ratio between land and building as the age of the building increases.

Obsolescence in Type of Construction.—It is generally believed that the present type of office building represents the highest possible development of these structures, and consequently that they will not suffer from obsolescence in type as have the older buildings. A study of the growth of the office building and of the purpose and plan of its design will easily convince anyone that it has by no means arrived at a state of perfection. There has been very little office building construction throughout the country for the past six years, due to the excessive cost of labor and material, so that the supply of office space in most cities is, at the present time, inadequate. As the cost of construction gets back to normal and as business conditions improve, there will be a revival of office building construction, and out of this revival is sure to come a new type of building.

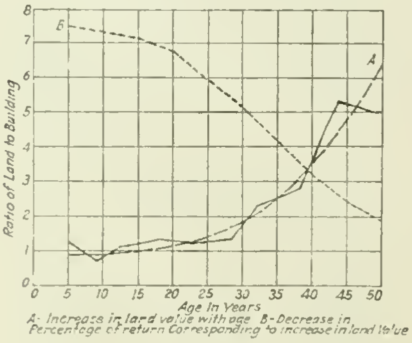

Chart II.

If office building owners and managers have learned any one thing during the past period of inflation, it has been the necessity of economical operation. The new type of office building will, therefore, be built primarily as an investment and designed not only for efficiency of layout to produce the greatest gross income, but also for economy of operation to give the lowest operating cost. Forerunners of this type are already appearing. These newer buildings are thoroughly standardized in their layout, and their lighting, plumbing and heating arrangements are such as to permit of the moving of interior partitions without affecting any of the mechanical equipment of the offices. In the proposed Dexter-Horton building, to be erected next year in Seattle, this standardization has been carried to a high state of development. The cost of alterations in this building should be but a small percentage of that experienced by the average building today. This plan of standardization was also adopted in the General Motors Building in Detroit. In one regard the latter building has gone a step further. In it they are using movable steel partitions that can be taken apart and reassembled for any new layout of office space desired. In fact, quite a number of buildings in cities requiring all steel interior construction are using these movable partitions. They are as yet expensive in their first cost and are not, by any means, perfect in their design. It is only a question of time, however, until partitions of this sort will be developed that will have the greatest flexibility and will be very economical in their operation.

The Heating and Ventilating Problem.—One of the difficult problems of operation of the present office building is that of heat and ventilation. The office building is one of the most wasteful users of heat, because its use is entirely in the hands of the tenants who waste it without regard to cost. The new type of building will probably be mechanically ventilated throughout (as is the Chicago, Burlington & Quincy R. R. office building in Chicago) with double glass windows permanently closed. In this way the air in the office building will be at all times not only purified, but either heated or cooled to the proper temperature and moistened to the proper humidity. A building so equipped would add very materially to the efficiency and health of its occupants, and consequently would attract tenants from buildings not so equipped.

Over $3,000,000,000 of Construction Started.—Construction started during the first 11 months of this year has amounted to $3,135,812,000, according to the F. W. Dodge Co. This is 45 per cent greater than the total for the corresponding period of last year, and 33 per cent greater than the total for the entire year 1921.

Interlocking Specification for the Regional Plan Los Angeles County

Prepared by the Committees of the Regional Planning Conference Passed Upon at the Regional Planning Conference, Glendale, Calif., Sept. 16, 1922

The district covered by the Regional Planning Conference is a central district (about 10 miles in diameter) surrounded by four sectors, divided by a north and south line and an east and west line intersecting at the center of Los Angeles, and extending outward to the county limits. The intent of these specifications is to cover the physical "civic" problems of this district with the purpose of co-ordinating all development efforts toward unified results.

The physical make-up of this "Commonwealth of Los Angeles" (somebody please name it) consists of a metropolitan or city center surrounded by many satellite sub-center cities and communities—all to be inter-connected by adequate transportation, by means of both rails and highways, to be supplied by an abundance of pure water, to be provided with sanitary sewers, and to have easy access to a system of parks and boulevards.

The individual identity of each separate community is to be recognized and encouraged, but for the common needs a surrender of authority to some central power is anticipated—leaving local problems which make the local character of each center or sub-center to be handled by local authorities.

Highways.—In planning a comprehensive system of highways throughout the regional district, the importance of Los Angeles as our focal city must be recognized, and the present system of highways should be augmented by securing rights of way for adequate "radial" and "circuit" highways. The following is a summary of specifications for developing a comprehensive highway system in the Regional Planning District:

(1) Select those lengths of existing streets that by location should fulfill the functions of "regional highways." Secure the rights of way for extending these highways and for widening them, to the end that a comprehensive system of "radial," "circuit" and "connecting" highways may be constructed throughout Los Angeles County.

(2) Fill in the necessary links of the "circuit" highway now largely existing around the city of Los Angeles at about five miles from the original Plaza, and select and develop radial major highways into the outlying territory, crossing the "regional" highways and other important cross connection highways at approximately half-mile intervals.

(3) Strive to make all major and regional highways not less than 80 ft. in width, with 10-ft. set-back for building lines, in order to provide for possible future widening if traffic demands additional width.

(4) Locate "regional highways," as by-passes to congested business centers, because through travel arteries should not be subjected to the congestion of local business, nor should they themselves add to any local business congestion by introducing a large volume of through travel into the business areas.

(5) Compile adequate topographical and engineering information as a basis for intelligent planning, and through competent advisors with knowledge of the recognized principles in city and regional planning, prepare a comprehensive plan and program for the location and development of a system of "regional highways," "major highways" and "highways" for Los Angeles County.

Sub-Divisions.—(1) A "master map" showing the location of present and proposed highways and boulevards should be prepared and filed in each city and in the county's surveyor's office for the guidance of subdividers. The city and county authorities should co-operate in keeping these maps up to date, and a united effort is to be made to secure a consistent layout of through streets and highways.

(2) There should be a minimum of cross-streets along each main artery of traffic, and long blocks along principal thoroughfares should be encouraged, with intermediate pedestrian and public utility "ways" about 20 ft. wide, located conveniently.

(3) A booklet or guide should be prepared reciting the various steps required to change raw land into subdivided areas, giving technical suggestions as to zoning, width of streets, size of lots, set-back lines, grades and best use of the topography to secure the highest use of the land.

Transportation.—(1) The transcontinental lines should be electrified.

(2) There should be a union terminal station in Los Angeles.

(3) Population centers and sub-centers should be so connected that rapid transportation of passengers and freight between such centers is possible.

(4) A system of rapid transit by rail from the center of Los Angeles to each satellite sub-center should be encouraged to work in conjunction with auto-bus terminals at all principal sub-centers, using the busses as a medium for collecting and distributing in the territory not served by rail transportation.

(5) Grade crossings should be eliminated as soon as economic conditions permit.

(6) A district entitled to transportation facilities, whether freight or passenger, should be furnished such facilities.

(7) The Los Angeles Harbor should be a port readily and freely accessible, whether approached from land or sea.

Sanitation.—(1) In developing a metropolitan sewage system, political boundaries should be ignored in order that the fullest co-operation may be had between communities and topographical areas logically grouped and co-operating where such interests are in common.

(2) A comprehensive sewerage survey—under some competent county agency, to be created for the purpose—dividing the county into such districts as may be necessary to properly provide permanent sanitary relief for all time, should combine as many cities and communities as can be properly served, and encourage any community planning sewage disposal to make their plans conform, not only for their own immediate work, but to fit into the final scheme for that district and the county as a whole.

(3) No city or community should be allowed to interfere with the health or comfort of its neighbors; neither should a city or community be permitted to pollute a stream course; underground water or a pleasure resort. The tremendous asset which the county has in its beaches must be protected at all hazards, and only the best sanitary conditions be permitted. The situation is one which justifies going beyond the actual sanitary requirements and making a contribution to what might be called sentiment, and which must for all time preclude criticism which might in any way affect the popularity of these natural playgrounds.

(4) In the organization of a "Metropolitan System," all cities and communities should be compelled to make their local sewage system an integral part of such broad and comprehensive scheme.

(5) The economic use of all treated sewage waters and by-products (such as fertilizer) should be encouraged, but, however, only on the theory that the treatment of sewage for irrigation or fertilizer is a function of agricultural development and not as a burden upon the sanitary system, as such, but the cost thereof should be borne entirely by the industry or land enjoying such benefits, if a community can in a more economical or sanitary manner otherwise dispose of its sewage.

(6) Until such time as conditions warrant, the expenditure of larger amounts, as part of the permanent plan of disposal, the interior communities, in solving their sewage problems, should be permitted to construct treatment works—the entire system to be so designated that it will become an integral part of the larger "Metropolitan Scheme."

Flood Control.—(1) Additional reservoirs in the mountains should be financed as soon as possible.

(2) As far as practicable these reservoirs should be designed to act as flood control adjuncts and also as water supply reservoirs.

(3) The channel protection work now under way should be completed.

Parks and Boulevards.—(1) All parkways and pleasure boulevards should be established as separate features from traffic highways.

(2) All parkways and pleasure boulevards, when located along river channels, arroyos, canyons and the sea coast, should be established so as to pass under all other lines of traffic. When located on ridges or mountain crests, they should be established so as to pass over all other lines of traffic, by bridges or viaducts. Briefly, no grade crossings should be permitted to exist.

(3) Parkways and pleasure boulevards, when established along channel embankments, can be beautified economically, artistically and with great scenic effect at low cost. As a utility, they provide easy means of construction for trunk sewers and

storm drains, and a rapid means of transportation in case of flood control work.

(4) Parkways and pleasure boulevards, when established along ridges and mountain crests, should be located so as to reach the most asvantageous view points and, as a utility, they will prove extremely valuable in providing rapid means of transportation in case of forest fires.

(5) As a further consideration, these parkways and pleasure boulevards serve to link up all beach reservations, picnic parks and camps now existing, and we recommend that beach reservations be established—these reservations to be for the free use of the public and not controlled by private parties.

(6) We recommend that picnic parks and camps be established throughout the district.

(7) We recommend that all principal natural drainage channels be acquired and controlled by the community for the highest public use.

(8) Patents to land in the forest areas are to be discouraged.

Zoning.—(1) Each city and all surrounding territory should be zoned to provide restricted areas for industry, for business and homes.

(2) As a rule, both sides of the street should be in the same zone.

(3) It is desirable to zone for "use," for "height" and for "set-back" lines.

Legislation.—(1) A Los Angeles County Planning Commission should be created to assist the supervisers in the consideration of regional planning problems.

(2) A metropolitan park and boulevard commission should be created, with power to acquire, improve and maintain a county-wide system of recreation places, including parks, parkways, boulevards, bathing beaches and camping grounds.

(3) Legislation should be provided to facilitate unified administration of planning problems, such as sewer, water, highways, parks and other physical problems not of local character.

Finance.—There should be a uniform assessment made for tax purposes throughout the district upon a basis of 100 per cent cash values instead of at various "ratios," as at present.

Topographical Map.—(1) A topographical map with 5-ft. intervals for the plain and 20-ft. contour intervals for the hills of the entire district, is desirable for all kinds of planning work.

(2) The cities and county have considerable data which should be co-ordinated, compiled and published.

(3) The County Surveyor's office should be charged with the responsibilty of making this data available.

(4) The County Supervisors have appropriated necessary funds and consummated an agreement with the U. S. Government whereby this survey will be completed and the maps printed in the near future.

Water Supply.—(1) Due to the lack of economical surface storage sites, most of the communities of Los Angeles County have been dependent upon the several large underground water basins for the major portion of their supply. Generally, these basins (with the exception of the San Fernando Valley, which has been kept up by return waters from irrigation with Owens River water) have shown a marked lowering of the water plane. There is, therefore, much need for greater conservation measures.

(2) Owing to the lack of economical surface storage sites, the necessary storage must be financed by combined flood control, irrigation and domestic interests. Fortunately, we already have the necessary county-wide organization in the Los Angeles County Flood Control District. This district is organized for both flood control and conservation, and therefore we need not stress here the necessary organization program, but pass to the essentials of such conservation.

(3) As the limit of development in the arid west is the water supply, it is necessary that all public and private developments be so carried out as to assist the conservation of water and the maintenance of its purity.

(4) Flood water should be conserved in mountain reservoirs and spread upon the gravel cones to replenish ground water basins. The spreading areas should be extended and with all channels held in public ownership so that they may be preserved and not encroached upon. Storm channels should provide for maximum percolation.

(5) In order to determine what may be accomplished by conservation measures, continuous records should be made of run-off passing from the foothill belt to the coastal plain and from the coastal plain wasting into the sea. The only measurements now available are those of run-off in the mountains.

(6) The great influx of people into the mountains is seriously menacing the purity of our mountain water and threatening the health of many communities. Mountain highways should be constructed on the ridges instead of in the canyons in order to minimize stream contamination and, also so as not to interfere with future storage reservoirs.

(7) Fifty per cent of the water used for domestic purposes in our cities passes out through the sewer system. Whenever practicable, this water should be reclaimed, either by using it as a purified effluent directly upon the land or by allowing it to flow down natural waterways in such a manner as to replenish underground water basins.

Methods of Constructing Substructure of Edmundston-Madawaska Bridge

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How Concreting for Piers Was Done with Hoisting Towers and Other Interesting Construction Features Described in Paper Presented Before St. John's Branch of Engineering Institute of Canada

By G. MC N. STEEVES.

An important new international highway bridge was constructed last year over the St. John River, connecting Edmundston, N. B., and Madawaska, Me.

The bank on the Canadian side is ledge rock, overlain with pockets of clay. The American bank is very compact gravel, with an 8-ft. layer of clay overburden. The river bed is composed of coarse gravel and boulders, varying from a foot to 3 ft. in thickness, overlying very hard sand and blue clay, mixed.

During high water periods, the current over the full width is swift, probably 8 miles per hour, but, owing to the sharp gradient, floods soon run off. During low water, the current is reduced to about 3 miles per hour, and is confined within a channel about 200 ft. wide, adjacent to the Canadian shore, the balance of the river being comparatively slack water. The width of the river at high water is about 850 ft. and at low water 200 ft. less. At low water the depth varies from 2 to 7 ft. at this crossing. All elevations are referred to mean sea level. Low water is elevation 441.85, and high water, the elevation of the boulder referred to, is 467.85.

The Substructure.—The substructure consists of two concrete abutments and three semi-reinforced concrete piers. The distance between face of ballast walls of each abutment and the center of next adjacent pier is 235 ft., 6 in., which is also the distance between piers.

Each pier rests on a footing course of varying depth in the case of each, the maximum being 10 ft. under pier 2. This footing course is built inside a sheet pile cofferdam, which in turn is enclosed within a cribwork protection and stone rip-rap. The top of footing course is elevation 442.0, or 0.15 above extreme low water.

The main body of the piers is rectangular in plan, with a triangular shaped cutwater on the up-stream end and a triangular shaped buttress on the down-stream end. The nose of the cutwater is protected by an 8 by 8 by ⅝-in. steel angle. The piers are 8 ft. 6 in. by 29 ft. at the top and 58.54 ft. high above the top of the footing course. The sides are battered 1 in 20.

The average elevation of river bed is 438.0. The footing course was required to extend at least 6 ft. below river bed. A suitable bearing was obtained at this minimum in the case of the two shore piers. A mattress of steel reinforcement of 1 in. square twisted rods was placed within a foot, or as near that as possible, of the bottom of the concrete of the footing course. The rods were spaced 12 in. in each direction. Vertical rods, at 12-in. centers, of the same dimensions were hooked into this mattress, and carried near the faces of the piers, as construction proceeded to within a few feet of the top of the pier. Horizontal ¾-in. square twisted reinforcing at 2 ft. centers was carried up with the verticals. Splices and intersections were wired with No. 16 gage Bates wire ties.

Abutments.—The Canadian abutment rests on solid rock. It is a type of "U" abutment, somewhat out of the ordinary in the design of the walls. The center line between trusses of the superstructure is eccentric downstream to the center line of the abutment, to permit the foot walk to be carried on the inside of the upstream wing wall. This accounts for a buttress on the lower side of the abutment. The sidewalk on the superstructure is to be cantilevered from the truss. Reinforcing bars of 1 in. square twisted steel were placed in the inside corners at the junction of the main wall with the wings. These were 12 ft. long and bent in the center to a right angle.

The foundation for the American abutment is fine, compact gravel, with 8 to 10 ft. of clay overburden. Owing to the presence of water at several points in the bank, adjacent to the site of the abutment, but not in the immediate vicinity, the original plans called for a pile foundation with an elaborate arrangement of batter piles to be driven. The carrying out of the original plan was attempted, but amounted to the driving of only one pile a distance of 4½ ft. under a 2,400-lb. hammer. The design was altered and the former level of excavation for footing course was lowered 5 ft., resulting in placing the foundations well inside the bank. Over the bottom of the excavation was placed a 3-in. layer of 1:3 grout, slightly worked into the bed to bond the same before placing the footing course.

Both abutments carry on the copings reinforced posts and pre-cast reinforced rails. This part of the work was done during cold weather. Aggregate was heated and hot water used in mixing. The forms were kept covered with straw until removed.

Concreting Towers for Piers.—The equipment used consisted of one ½-yd. and one 1/3 yd. Smith mixer; two A-frame derricks, with 28-ft. and 35-ft. booms, respectively; two direct-connected centrifugal pumps of 1,000 gal. per minute capacity; one mine hoist with 36-in. drum, and a 1¼-in. wire rope cable on which a ferry scow was operated. Smaller equipment comprised boiler feed pumps, buckets, skips, blocks and tackle. For night work, electric lighting was installed and supplied by flood lights ranging between 300-watt and 1,000-watt lamps.

Two concrete hoisting towers were used. A single wooden tower, 80 ft. high, placed the concrete in pier 3. This carried a self-dumping elevator bucket. discharging the concrete into a hopper on a sliding frame on the face of the tower, from which it was spouted into the pier forms.

For the construction of piers Nos. 1 and 2 a double tower was erected, first at pier 1. After its completion the tower was taken down and moved to pier No. 2. This tower was 75 ft. high, and in plan was 7 ft. 6 in. by 15 ft. In each of the bays an elevating cage was operated which carried the concrete in two-wheeled buggies to the hoppers on the face of the tower. The cages were raised by a ⅝-in. wire rope, passing through a system of sheaves and around the drum of the mine hoist, in such a way that when one cage was going up the one in the other bay was coming down.

Both towers were guyed with two sets of ½-in. wire guys, one set placed about midway and the second set near the top of the tower. A boom 18 ft. long was placed near the top of each tower, and was used in hoisting the form sections, and sliding hopper frames. Owing to the necessity of having the towers adjacent to the piers, ordinary spouting equipment was not feasible. The movable frame carrying the hoppers on the tower bracing at any desired elevation as the work progressed.

The single tower was built of 4 by 4-in. corner posts, 2 by 6-in. walings, and 1 by 6-in. braces. All joints were spiked. The double tower was built of 6 by 6-in. corner posts, with 2 by 5-in. braces and walings. All joints on the latter tower were matchmarked and secured with ½-in. screw bolts. This permits of easy dismantling and re-assembling.

Piers Connected by Pontoon Bridge.—A pontoon bridge connected the first and second piers. There were several pontoons 6 ft. wide, 18 ft. long, and 3 ft. 6 in. deep, constructed of 2 in. plank. They were placed 18 ft. centers, and decked over with 6 by 6-in. stringers and 2-in. plank. The pontoons were held in place by lines fastened from the bow to a wire cable stretched from the nose protection crib of each pier. This method of crossing was adopted after it was found improbable that a pile trestle could be driven sufficiently stable in the hard river bed to withstand a sudden rise of water. That there were three million feet of logs in the storage dams at the head of the river, awaiting favorable conditions to come down, was also a factor in deciding on a form of construction that could be easily removed in the event of such emergency. Experience proved that logs could be guided by this obstruction more easily and with less danger to the structure than through a trestle. Logs would easily pass under the pontoons. All construction material required in pier No. 2 was moved over this bridge.

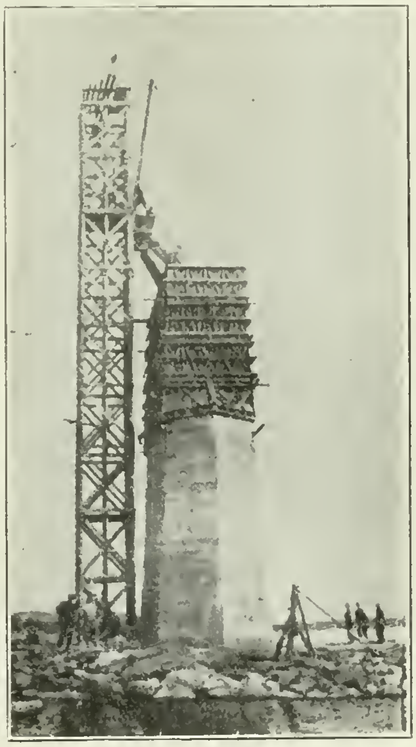


Fig. 1.—Concreting Operations at Pier No. 1.

A good quality gravel was obtained from the head of Madawaska Island, about a mile below the site. "Canada" cement was used in this work. It was held after arrival for 30 days awaiting reports of tests from the government testing laboratory.

Construction Methods at Pier 2.—The center of the pier for placing protection cribs was obtained by direct chainage from shore. A 300-ft. tape was used, supported on gas-pipe standards driven into the bed of the river, and carrying on the top a "U" made up of tees and ells. The side lines of cribs were set with a box sextant.

Each protection cribwork consisted of four separate cribs: (1) Nose piece 46 ft. 10 in. across the base, and 23 ft. 2 in. perpendicular distance to the apex: (2) Two side cribs, 62 ft. 10 in. long and 9 ft. 0 in. wide; (3) one closure crib 46 ft. 10 in. by 9 ft. 0 in., extending across the down-stream ends of the last two cribs and the enclosed space between them. The cribs were built of 8 in. to 10 in. logs in 8 ft. bays. Ballast floors were provided. When completed and finally in place, the cribs were to stand 2 ft. above low water. The maximum height built was 8 ft. When finally in place, the cribs were filled with stone and clay, and banked on the outside with clay, the latter to assist in making watertight the cofferdam subsequently to be built inside. The center line of the pier was now accurately set by triangulation, and checked by chainage. From these the lines to which the cofferdam was to be built were laid on the cribwork. The cofferdam was also the form work for the foundation course.

The Cofferdam.—The cofferdam consisted of sheet piling built up of two 2 by 8 in. planks, half lapped, spiked together; preparatory to driving, the piling was stood on end around a frame composed of timbers varying in size from 6 by 8 in. to 12 by 12 in., according to the depth it was anticipated the piling would be driven. From the character of the material of the river bed, it was reasonably certain that the sheeting would not stand hard driving. A power hammer was therefore installed.

Up to this point, the conditions obtaining in all three pier sites were similar. From borings made on this pier site, it was found that the material to be excavated contained more sand, and the hard stratum on which the footing course was to rest, was 4 ft. deeper than at the other piers. Timbers 12 by 12 in. were used in the framework for this cofferdam.

The water inside the protection crib was 4 ft. deep. The river bed was roughly leveled off, and a frame was built, the outside dimensions of which corresponded to the dimensions of the footing course. This was centered and held in position. Short posts about 4 ft. long were stood up on the first frame, and a second frame was constructed on the top of these posts. This double frame was weighted and sunk. The sheeting was then placed around the four sides of the framework. Clay puddle was next placed in the 6-ft. space between the outside of the cofferdam and the crib protection, to a height of 2 ft. above the water level. The water was then pumped out to permit of excavation. This was done by hand, the material loaded into skips, and dumped outside the cribwork. The material was too hard to be dug with a clam shell. As the bottom was lowered the sheeting was driven with large wooden mauls. Great care had to be exercised in driving not to broom the pointed ends of the sheeting. The driving followed closely the hand picking at the foot of each pile.

As the excavation was lowered, additional frames were set in under the first two. Cross timbers were jacked into prevent the sheeting crowding, a tendency that was ever present owing to the large number of boulders that had to be removed away from the cutting edge. These had to be broken up, causing a disturbance of the bed, outside of the sheeting, which increased the leakage to such an extent that eventually two centrifugal suction pumps, one 6 in. and one 8 in., were required to keep the water down to the level at which excavation could be carried on.

In other piers, it had been possible to have the caisson dry enough to concrete up to a set of walings, remove these and proceed with the concrete. In the present case, this was not possible, because of the leaks, and the foundation course was deposited under water to a depth of 5 ft. above which the amount of leakage was negligible.

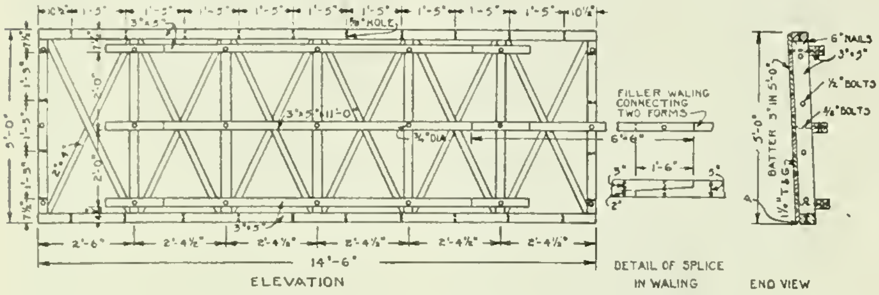


Fig. 2.—Details of Panel Form.

In end view A indicates sheeting set back from edge of plate ¼ in. on each form. When adjacent forms are bolted up, the space is filled with a ½-in. strip. This prevents brooming of edge.

The timber wales and braces were replaced by 80-lb. rails and left in the concrete.

Concrete was deposited under water by means of bottom dump buckets. After 4 days, the water was pumped off, the surface thoroughly broomed, the reinforcing steel mattress laid, and concreting resumed to top of footing course.

The Forms.—Wooden panel forms, of the type illustrated in Fig. 2, were employed. Specials were re-used on all piers in a corresponding position three times. The regular rectangular form was used over and over again, as often as required. Form lumber was 1¼ in t. & g. clear spruce, fastened to 3 by 5 in. framework. The height of the sections was 5 ft., which gave a batter of 3 in. in each lift. The forms were laid out and built on a specially constructed platform, where the outline of the horizontal plane through the pier at each succeeding 5 ft. lift could be accurately laid out. When placed on the pier, the forms fitted perfectly. Check levels for the bridge seat differed from the elevation of the forms by not more than ¼ in.

Forms were tied together with two wire ties to each bolt, projecting through the forms. These ties were previously prepared on Newburgh's wire tie machine. Any slack was taken up by twisting the bolt head against a wrench held on the nut. After the concrete had set four or five hours, the head was broken by giving the bolt a backward turn.

The forms were left on for three days. To remove them, the bolts holding the wire were backed out, then the bolts holding adjacent sections were taken out. A sling attached to the fall of the tower derrick was hooked into the upper waling of the form section, which was then wedged off at the bottom, and the form was raised to the next lift, or lowered to the ground as required.

Tongued and grooved lumber did not prove entirely satisfactory. The dampness in the concrete caused the tongue to swell, and pushed the inner side of the groove into the concrete. With forms new, this was more marked than after they had been used several times. Before being re-used, forms were planed and oiled. Lumber dressed on three sides was used for forms on the abutments, and proved entirely satisfactory.

The concrete used in the bridge seats and copings was mixed in the proportions of 1:2:4. For the rest of the work it was 1:3:5, except for sidewaiks and railings, for which it was 1:3 mortar.

Twenty-nine carloads of cement, 150,000 lb. of steel reinforcing, and over 5,000 cu. yd. of gravel were used in the job.

Work was started May 10, and completed Nov 26, 1921. The date of completion set by the contract was Feb. 20, 1922. The maximum number of men employed at one time was 120.

The contractors were D. C. Burpee & Son, Devon, N. B., with whom the writer was associated. S. J. Chapleau, was engineer in charge for the Canadian Department of Public Works and had L. DeB. Roy, asisstant engineer, as his representative on the work. L. N. Edwards represented the Maine State Highway Commission, his deputy on the work being H. E. Towne. A. W. Gregory of the Canadian Department of Public Works, represented both governments as inspector of materials.

Am. Soc. M. E. Prize Awards.—For a paper on "Steam Formulas" Prof. Robert C. H. Heck of Rutgers College has been awarded life membership in the American Society of Mechanical Engineers. Junior prizes of the society went to R. H. Heilman, industrial fellow at the Mellon Institute, Pittsburgh; and F. L. Kallam, graduate student at Leland Stanford Junior University. Heilman's paper dealt with "Heat Losses from Bare and Covered Wrought-Iron Pipe at Temperatures up to Eight Hundred Degrees Fahrenheit." Kallam won the honor for a "Preliminary Report on the Investigation of the Thermal Conductivity of Liquids." No student prize was awarded this year. Walter M. McFarland of New York was chairman of the Committee on Awards and Prizes.

Structural Steel Sales in November.—Sales of fabricated structural steel in November, according to reports received by the U. S. Department of Commerce through the Bureau of the census was 99,040 tons or 46.8 per cent of shop capacity. In October sales totaled 121,150 tons or 57.3 per cent of shop capacity.

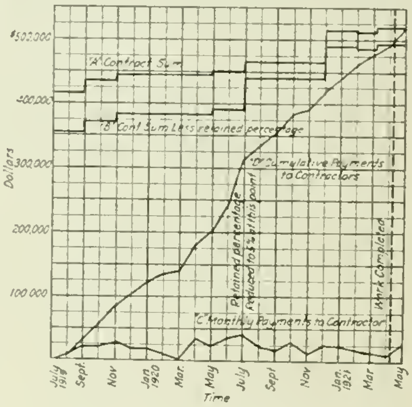
A Graphical Method of Determining the Approximate Date of Completion of a Building Operation

By RICHARD P. WALLIS,
The Lundoff-Bicknell Co., General Contractors, Cleveland, O.

A graphical method of satisfactorily showing the financial status of a job at any time during the period of construction is of interest to contractors, architects and owners.

Such a graph if correctly drawn will show not only the balance owing the contractor from month to month, but will serve as a means of forecasting the approximate date of the completion of a project as a check against the usual completion schedule planned by the contractor.

The graph should be laid out at a convenient scale with time as the abscissa and dollars as the ordinate. Four curves should be shown: A, total contract sum; B, total contract sum less the percentage; C, individual monthly payments to contractor; D, cumulative monthly payments to contractor. These curves will vary from month to month as extras and credits are applied to the contract sum and as payments are made to the contractor based on the architect's certificate.



Graph for Determining Approximate Date of Completion of Typical Building Operation.

Projecting curves, B and D, ahead at any stage in the operations until they intersect, making due allowance for possible contingencies such as strikes, future alterations to the contract, etc., give a point on the scale of abscissae that represents the approximate date of completion of the work under consideration.

Such a graph is shown in the accompanying illustration. These curves represent an actual case in which the completion date very closely checked the date estimated in this manner.

Nearly 18 Million Residences in U. S.—The total number of residence houses in the United States, not including those on farms, was 17,600,000 in 1920, according to figures recently issued by the census bureau at Washington. Of that number 7,195,000 or 40.9 per cent were owned by their occupants and of these 2,855,000 or 39.7 per cent were mortgaged. The total amount of these mortgages is estimated by the bureau to be $6,000,000,000, while the total value of the homes is placed at $14,099,000,000. The ratio of the indebtedness to the value is 42.6 per cent.

Code of Ethics Adopted By Am. Soc. M. E.

Adoption of a code of ethics governing its membership of approximately 20,000, is announced by the American Society of Mechanical Engineers. The code commands loyalty to country, personal honor, fairness to contractors and workers, and interest in the public welfare. Betrayal of professional confidences, undignified or misleading advertising, and questionable professional associations and practices are prohibited.

The text of the code, as given out in New York City by John L. Harrington of Kansas City, now president of the American Society of Mechanical Engineers, follows:

"Engineering work has become an increasingly important factor in the progress of civilization and in the welfare of the community. The engineering profession is held responsible for the planning, construction and operation of such work and is entitled to the position and authority which will enable it to discharge this responsibility and to render effective service to humanity.

"That the dignity of their chosen profession may be maintained, it is the duty of all engineers to conduct themselves according to the principles of the following code of ethics:

"1. The engineer will carry on his professional work in a spirit of fairnes to employes and contractors, fidelity to clients and employers, loyalty to his country and devotion to high ideals of courtesy and personal honor.

"2. He will refrain from associating himself with or allowing the use of his name by an enterprise of questionable character.

"3. He will advertise only in a dignified manner, being careful to avoid misleading statements.

"4. He will regard as confidential any information obtained by him as to the business affairs and technical methods or processes of a client or employer.

"5. He will inform a client or employer of any business connections, interest or affiliations which might influence his judgment or impair the disinterested quality of his services.

"6. He will refrain from using any improper or questionable methods of soliciting professional work and will decline to pay or to accept commissions for securing such work.

"7. He will accept compensation, financial or otherwise, for a particular advice, from one source only, except with the full knowledge and consent of all interested parties.

"8. He will not use unfair means to win professional advancement or to injure the chances of another engineer to secure and hold employment.

"9. He will co-operate in upbuilding the engineering profession by exchanging general information and experience with his fellow engineers and students of engineering and also by contributing to work of engineering societies, schools of applied science and the technical press.

"10. He will interest himself in the public welfare in behalf of which he will be ready to apply his special knowledge, skill and training for the use and benefit of mankind."

The joint committee which drew up the code was composed as follows:

American Society of Civil Engineers—C. C. Elwell, New Haven, Conn.; A. M. Hunt, New York.

American Institute of Mining and Metallurgical Engineers — J. Parke Channing and Philip W. Henry, New York.

American Society of Mechanical Engineers—Prof. A. G. Christie, Johns Hopkins University, Baltimore; H. J. Hinchey, Chicago; Charles T. Main, Boston; J. V. Martenis, Minneapolis; Robert Sibley, San Francisco.

American Institute of Electrical Engineers—Prof. Comfort A. Adams, Harvard University; C. Paccioli, Pittsfield, Mass.; George F. Sever, Toronto, Ont.; L. B. Stillwell, New York.

American Society of Heating and Ventilating Engineers — Frank T. Chapman and Perry West, New York; S. A. Jellett, Philadelphia.

Calculating Stresses in a Roof Truss

A Solution of a New Problem Described in The Cornell Civil Engineer

By ARTHUR W. ENGEL

Designer, American Bridge Co.

The problem is to find the stresses in a truss for a mill building located where there are very heavy winds and no snow. The wind load assumed is 40 lbs. per square foot when blowing against a vertical surface. By the Duchemin Formula this gives 30 lbs. per square foot acting normally to the roof, which has a slope of 6 in in 1 ft.

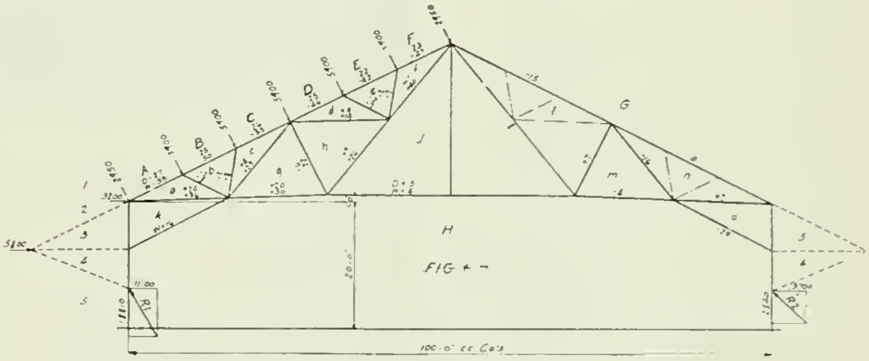


Fig. 1.

The dead load, which includes structural steel and corrugated steel roofing, is assumed to be 12 lbs. per square foot of horizontal projection of roof and the trusses are spaced 21 ft. center to center. The bottom chord is broken so that no computations need be made in the drawing room or shop for camber and the bottom chord bracing angles can be be turned with legs down if desired without reducing the clearance.

The columns are to be "fixed" at the base and the point of contra-flexure is taken at a point half-way between the floor level and the knee brace. Auxiliary members are introduced as shown dotted in Fig. 1 that the problem may be solved graphically.

The dead load amounts to 2100 lbs. per panel point of top chord. The dead load stresses are given above the wind load stresses.

The reactions due to wind are found analytically. It is assumed that the horizontal thrust is divided equally between two columns. The horizontal component of R1 is reduced by a direct wind load from the left amounting to 2600 lbs. The vertical component of R1 is found by taking moments about the point of contra-flexure of the right hand column. After plotting the loads and reactions as shown in Fig. 2, we begin at the point of contra-flexure of the left hand column and continue the stress diagram, taking members counter-clockwise. At the fourth panel point of the top chords we encounter three unknown stresses, but this can be solved easily by computing the stress in Hj taking moments about the peak of the truss and finding the stress in big graphically in the stress diagram.

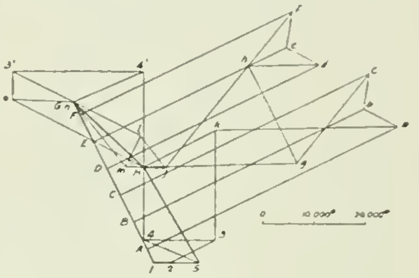


Fig. 2.

The members shown by dot and dash lines have no stress due to wind when the wind is blowing from the left.

When the auxiliary members are removed, the stresses in the columns must be revised as the stress in the section below the knee brace, is equal to the vertical component of the reaction and the stress diagram for the joint at foot of knee brace will not close as there is bending in the column at that point.

If the truss is changed to type shown in Fig. 3, an auxiliary member must be introduced as shown by dotted line or the stress in third panel of the bottom chord can be found analytically to overcome the difficulty

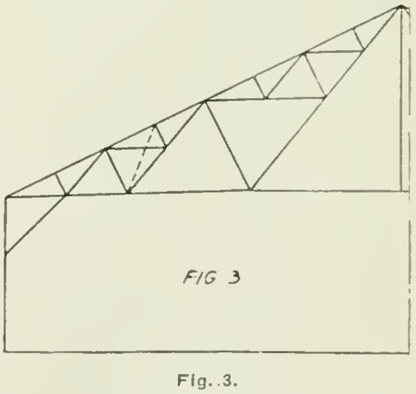


Fig. 3.

when three unknowns are encountered at a joint. In this type of truss the slope of the knee brace will cause the stresses in the bottom and top chords to increase, for in the diagram if Hk becomes steeper, Ka and Aa increase in length.

In proportioning the members those having a reversal of stress should be made sufficiently strong to carry the maximum stress plus one-half the minimum, provided no member has less section than required by either the tension or the compression stress acting alone.

The rivet connections should be made of sufficient strength to take the sum of the stresses.

Storing Construction Equipment

The way in which construction machinery is stored and taken care of when not in use has a very vital bearing on the way it will perform when put back into service, and also on the time required to get it ready for use after it has lain in storage for some time. It isn't reasonable to expect that when you dump a timber derrick on the ground with all the metal parts attached and make no effort to protect either metal or timber from the elements, you can go out in the spring and find your derrick all ship-shape and ready to set up and put to work. Even if nothing has been stolen the timbers are liable to be checked and warped, the metal parts rusted, and the sheaves sized on their shafts. All of which means, of course, that it will take time and money to put the derrick back into good working order.

Or take the case of a hoisting engine which has been hauled in from a job and "stored" out in the open with the stack open to all the weather that a versatile climate can brew; the shafts and other bright metal parts unprotected and the brass fittings left on to gladden some pilferer's heart.

No one in his right mind would think of leaving several thousand dollars in cash kicking around some back lot, and it is scarcely less pardonable to do the same thing with expensive equipment. Hoisting machinery can be stored adequately without going to much expense either for storage sheds or yard space. An interesting account of how the George J. Grant Co., a large construction concern of St. Paul, Minn., provides satisfactory storage facilities at moderate cost is given in a recent issue of the American Builder, from which the matter in this article is taken.

Location of Storage Yard.—The site of the George J. Grant storage yard is a level sandy tract formerly the site of the company's sand and gravel operation, from which about 500,000 cu. yd. of sand and gravel were taken. After the sand and gravel had all been removed down to the street level and the operation was worked out, the Grant Company fenced off a section of it, erected storage sheds, etc., and established it as a storage yard for their contracting equipment. The level sandy nature of the soil insured good drainage and the plot is conveniently located with reference to railroads and paved streets.

At this place are located the company's carpenter shop, machine shop, blacksmith shop, tool house, garage and storage sheds for derricks, hoisting engines, etc. Incoming and outgoing machinery is handled by a wooden stiff-leg derrick operated by a steam hoisting engine.

Storage of Derricks.—The item of wooden stiff-leg derricks alone presents a real problem in storing and handling at the plant of the George J. Grant Co., for they have 25 of these derricks. As soon as any of these rigs come back from a job they are taken apart and given two coats of battleship gray. The paint used is pure white lead and oil, with enough lampblack added to produce the gray color. After being painted, all the metal parts are removed and oiled thoroughly with heavy lubricating oil, after which they are marked and stored in the tool house.

The timbers are taken to the timber storage shed, a structure 150 ft. long, 50 ft. wide, and open at the ends to give ventilation and to permit teams and trucks to be driven through. The shed is built of wood, with corrugated iron sides, and the roof is covered with roofing paper. The shed frame is made of good sized timbers and is strongly braced and supported. The main upright timbers are fourteen by fourteens, which support five iron cross beams by means of which, and a hand-power crab, the derrick timbers are loaded and unloaded.

Five large iron beams are used as sills on which the timbers are piled. Five cross-pieces of two-by-four, 9 feet apart, are placed between each tier of timbers. This, of course, is to insure that the air will circulate freely around the timbers, keeping them thoroughly dry.

When timbers are piled in the shed care is taken to place them so that any belly or sag acquired in service will be gradually corrected by the weight of the timbers in the pile. This is done by piling the timbers so that the sag will curve upward.

Taking Care of Hoisting Engines.—When a hoisting engine comes in off a job it is taken to the machine shop, knocked down and overhauled by machinists. All the fittings are removed and oiled with heavy lubricating oil, after which they are packed in marked and numbered boxes, so that they can be found readily when it is desired to reassemble the engine.

In order to protect the hoist during its period of idleness the bearings are oiled to prevent rusting, the cylinder head is removed and the cylinder wiped dry on the inside and coated with oil to prevent rusting. Packing is removed from stuffing boxes to keep the rods from rusting.

All bright parts of the engine, such as the piston rod, connecting rod, crank disc, etc., are slushed with heavy grease. This grease coating is a good rust preventive, but it has a tendency to thin out on the upper sides of the parts. A better preparation, if the machine is apt to be in storage for a considerable length of time, is a mixture of white lead and tallow melted together. This coating will prevent rusting and stay in place until it is desired to remove it. It can be taken off readily with kerosene.

The boilers and frames of the hoists are stored in a weather tight shed 400 ft. long and 50 ft. wide. This shed is covered with corrugated iron and is substantially built to keep out prowlers. Before the boilers are drained a quantity of crude oil is put in on top of the water, which is then allowed to run out slowly. As the water level sinks a coating of oil is left on the tubes and plates, effectually protecting them against rust.

Dinkey locomotives, concrete mixers, gasoline engines, etc., are stored in the same shed as the hoisting engines.

The cabs of the steam shovels stored out in the yard are made as weather tight as possible, and all small parts are removed and stored in the tool house.

Form timbers, wheelbarrows and similar equipment is stored in the open, but care is taken in stacking this material to prevent deterioration during storage.

All small equipment, such as shovels, picks, hammers, wire rope blocks, guy tighteners, clips, etc., are stored in the tool house. Every piece is cleaned and oiled and put away carefully. All clips are removed from the wire rope, cleaned, oiled and the nuts worked back and forth a few times to make sure that the oil covers the threads of the U-bolt. After this the clips are slung on a wire and hung up where they'll be kept dry and in good condition. Sheaves are cleaned and oiled and piled on shelves. Wire rope is lubricated and carefully coiled or stored on reels.

About 20 men are employed around the shops and yards during the winter months. This number includes machinists, carpenters, barn men and laborers. Three men are employed at the storage plant all year 'round, doing odd jobs, such as repairing wagons and wheel barrows, sorting lumber, etc.

The Canine "Watchmen."—Perhaps the most unique feature of this well arranged and well managed equipment store-yard is the watchmen who protect the stored equipment from thieves and prowlers. These watchmen are Airedale and Police dogs; all alert, sharp toothed, and fast as greased lightning. They are trained as "watchmen" from puppyhood, and know their business from A to Z. Each dog has its beat, which it traverses in run-way chains; that is a chain with a ring over a long trolley wire.

Blasting Down a Brick Stack

Felling of an old smokestack was recently accomplished with the aid of dynamite at the Nesbit Mine of the St. Bernard Mining Co., Earlington, Ky. The stack was 104 ft. high and 9 ft. square at the base. It was constructed 37 years ago, but had been abandoned because the mine has lately been electrified.

The brick at base was 30 in. thick. Eight holes were drilled in the side on which it was desired to have the stack fall. These holes were 18 in. deep and 12 in. apart. On the adjoining sides, three holes were drilled 6, 8 and 18 in. deep, respectively. One-half cartridge of 60 per cent dynamite was used in each hole. The two holes in the center of the row of eight holes were fired first; the remaining holes in the same row were set off next; the holes on the adjoining sides being fired last along with a mudcap charge placed above the first row of holes. The mudcap charge consisted of 11 cartridges. The charges were primed with electric blasting caps and fired with a blasting machine. The total cost for explosives and detonators was $2.91.

Boilers were located on two sides of the smokestack and a new mine fan was under construction nearby. The work of razing the stack was entirely satisfactory, the stack falling where planned, and resulting in no damage to adjoining buildings and equipment.

The work was done by Mr. H. T. J. Duffey of the Technical Bureau of E. I. du Pont de Nemours & Co.

A 300-ft. Span Plain Concrete Bridge

From Le Genie Civil, Paris.

The bridge over the River Lot at Villeneuve is unique, inasmuch as it consists of two parallel arches of 300 ft. span built of concrete without reinforcement. The erection was begun in 1914, and the centering was removed in 1915, but no further work was done until four years later, with the result that the bridge was finished less than a year ago. The roadway of the bridge, including two footpaths, has a total width of 36 ft. The two supporting arches are 16 ft. apart. The designer claims that the avoidance of reinforcement is economical, because it enables various simplifications to be effected in cases where the superincumbent weight is not excessive.

Bridge Over River Lot at Villeneuve, France.

The specifications issued with the request for tenders did not mention the composition of the concrete, but simply stated that it must have a compression strength of at least 3,360 lb. per square inch after 90 days. The sand and gravel actually used were obtained from the River Lot.

The foundations of the roadway are of reinforced concrete, and consist of a series of slightly reinforced concrete piers and a flat foundation stretching right across the river, this table being also reinforced. The upper part of the bridge is faced with bricks. The parapets are of reinforced brickwork.

During the years 1915-1919, when the plain concrete arches were left unsupported by any centering and without the ties formed by the superstructure, they sustained several severe storms and floods without the least harm.

Rail Orders in 1922. According to The Iron Age orders placed during the year for 1922 rolling amounted to nearly 500,000 tons, while contracts closed for 1923 delivery account for about 2,000,000 tons more, of which 750,000 tons will be furnished by Chicago mills. Reference to past records shows that the consumption by American roads during the eight years, 1914 to 1921, inclusive, averaged 2,007,970 tons, and during the 13 years, 1901 to 1913 inclusive, 2,815,558 tons. The record year was 1906 with 3,654,794 tons.

Improvements in Structural Materials

From The Times Engineering Supplement, London.

In his address Nov. 7 as president of the Institution of Civil Engineers, Dr. W. H. Maw dealt with the progress that has been made towards the solution of some of the unsolved problems of engineering, to which he referred in his James Forrest lecture nineteen years ago.

The subject to which he devoted most attention was the improvement in materials of construction, especially in connection with the building of long span bridges. From improvement in structural design he saw no great chance of material aid, but he thought there are better prospects from the reduction of the so-called "factors of safety." Allowances for uncertainties as to the stresses to which the structure may be exposed must remain matters to be settled by the engineer responsible, but allowances for uncertainties as to the quality of the materials come under a different category. They would not be required at all if the engineer could be absolutely certain of the quality of all the materials used and of the soundness of the workmanship, and there appear to be good reasons for supposing that under existing conditions their amount could be materially reduced as compared with that considered necessary even ten years ago. During that period vast improvements have been made in the processes of steel manufacture, especially in the direction of securing uniformity of quality, and the facilities for thorough testing and inspection have enormously increased.

The most hopeful line of progress in the construction of bridges of exceptional span appears to lie in the improvement of alloy steels and their thermal and mechanical improvement. In structures such as long span bridges, in which the weight of the structure itself forms the larger portion of the total weight supported, the importance of the property of the material denoted as "specific tenacity" is exceedingly great; and the successful manufacture on a commercial scale of various high-quality alloy steels has substantially enlarged the limits of the practically permissible spans of the different types of bridges. In the specification issued last year for the proposed 1,600 ft. span cantilever bridge at Sydney the tensile stresses permitted for carbon steel were 20,000 lb. per sq. in. for eyebars and 18,000 lb. for riveted members, while for nickel steel or chrome steel these stresses were increased by 40 per cent, or in the case of pure tension by 45 per cent. If the lower of these permissible stresses is taken and applied to a bridge of such design and span that if it were constructed of carbon steel the weight of the structure would be four times the useful load carried, and then for every four tons of carbon steel replaced by nickel steel there would be a saving of weight of about 1.15 ton.

Among the light non-ferrous alloys developed during the war was that known as the "A" alloy, containing 67 per cent of aluminum, 20 per cent of zinc and 3 per cent of copper. With a specific gravity of 3.1, it has in the cast state an ultimate tensile strength of 12.6 tons per sq. in., but by forging and hot rolling into rods 1¼ in. in diameter the ultimate strength is raised to 26.9 tons. Its "specific tenacity" determined by dividing the ultimate strength in tons per sq. in. by the weight in pounds of one cubic inch of the metal, is 262, whereas for steel having an ultimate strength of 30 tons the specific tenacity by the same formula would be only 105. If it were justifiable to assume that the practical relative values of the "A" alloy and ordinary carbon steel were strictly proportional to their specific tenacity number, the weight of alloy required to replace four tons of carbon steel would be only 1.6 ton, a saving of 2.4 tons. Even if, on a much less optimistic view, the permissible working stress of the alloy is taken as only three-fourths of that of ordinary carbon steel, the cross sectional area of the members of the bridge would have to be increased in the ratio of four to three as compared with those necessary for the steel. But the specific gravity of the "A" alloy is only 3.1 as against 7.8 for the steel, so that the weight of the alloy required to replace the four tons of steel would be only 2.12 tons, or, in other words, nearly half the dead load would be saved. The general result would thus be about the same as that which would follow the use of steel of such a quality that it could safely be subjected to a working stress twice as great as that permissible with ordinary carbon steel. But it must also be borne in mind, that as the scantlings of the members of the bridge, if made of the light alloy, would be increased and the ratio of the length to the radius of gyration thus made more favorable, the saving of weight may be regarded as applying fully to the parts in compression as well as those in tension, which would not be the case if steel of high tensional strength were used.

College Scholarship Awarded for Essay on Good Roads.—Karl G. Pearson, 17-year-old student in Eastern High School, Washington, District of Columbia, won the Harvey S. Firestone Four Years' University Scholarship offered in connection with the 1922 National Good Roads Essay Contest, according to announcement from the offices of the Highway Education Board. Pearson is a native of Lindsborg, Kans. His essay entitled "How Good Roads Are Developing My Community," was chosen as the best of approximately 250,000 papers submitted in a contest conducted with the co-operation of extension divisions of state universities and state departments of public instruction. The scholarship, given annually by H. S. Firestone, Akron, O., for the best essay on a subject pertaining to good roads, provides tuition and all reasonable expenses during four years at college, and is the greatest single educational award offered in the United States. It is valued at not less than $4,000.

Paint as a Protection for Steel Structures

Fundamental Requirements in Use of Paint for Protecting Steel Outlined in Paper Presented Oct. 26 Before Montreal Branch of the Engineering Institute of Canada

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The importance of arresting corrosion is admitted by engineers as it is known that steel will decay, if natural agencies are allowed to act on it, more rapidly than any other material used in construction. The transactions of almost every engineering society include papers on this subject—all kinds of theories have been advanced and suggestions submitted, but the subject has not yet attained the attention which its importance demands.

Facts Which Have Militated Against Proper Consideration of Corrosion.—Practically the whole development of steel construction has occurred during the past 50 years, while the electro-chemical explanation of corrosion has been advanced, made the basis of tests and been generally accepted only within the past 20 years. It is evident therefore that for about 30 years the whole subject of corrosion was indefinite in the minds of many and few sound methods were advanced to combat it.

When one considers that practical exposure tests of selected paints require from three to four years for preliminary investigations before the qualities of each film can be determined, and thereafter from 6 to 10 years to obtain the comparative results for service efficiency of the combined films, one can readily appreciate that only within the past decade have the anti-corrosive merits of some paint ingredients been truly appreciated.

It is necessary in the manufacture of paints to test chemically, pigments, gums and oils used, prior to their incorporation in the paint, to insure freedom from undesirable impurities. In the physical laboratory also, many preliminary tests can be made to ascertain if a film has the desired qualities, but just as accelerated physical laboratory tests do not indicate the action which takes place gradually over an extended period between pigments and vehicle under exposure, so chemical analysis, after the paint is manufactured, does not indicate—except perhaps in elementary paints—the quality of ingredients, skill of compounding or service value of the paint.

Authorities have recognized for a long time that by aging, in some cases for several years, oils, varnishes and mixture of these with pigments, very much enhanced service value is obtained for the product. Chemical laboratory analysis, even in conjunction with accelerated physical tests, does not indicate or take into consideration this aging of materials. Therefore, between paints of similar analysis there is no assurance of equal service value. The only true tests are those where paints are subjected to service exposure tests under conditions to which the paint will be subjected. These necessarily involve time.

Importance of Exposure Tests.—The importance of actual exposure tests and the doubtful value of accelerated laboratory tests is mentioned by all authorities who have had an opportunity to compare results. A. S. Cushman and H. A. Gardiner in their study of "Corrosion and Preservation of Iron and Steel," emphasize this point as follows: "The results of the acceleration tests may be taken as fairly good evidence of how the paint will work in practice, but a series of practical exposure tests should also be started so that definite knowledge can be obtained in regard to their protective value." Again, they state that, "Owing to the nature of corrosion it is probably true that no perfectly reliable acceleration test for corrosion resistance can be devised. Corrosion is the natural process of rust formation; that is to say, in very slightly acid media, it is a question of comparatively slow growth under special conditions, and any effort to hasten the action changes all the conditions ot equilibrium, producing an entirely different order of phenomena."

The opinion that the physical state ot the paint after it is manufactured is a more vital factor than the composition of the paint and the importance of exposure tests to demonstrate paint value, is also emphasized by J. C. Smith in his paper to the International Association for Testing Materials at Copenhagen in 1909, as follows: "Although opinions vary as to what is theoretically the best pigments or, more correctly, combinations of pigments, for the manufacture of protective coatings, the general consensus of technical opinion seems gradually to be that with certain more or less obvious reservations, the composition of the paint is less important than its physical state, and that one pigment or blend of pigments is more efficient than another as the basis for a protective paint, mainly according to the degree in which it tends to produce certain definite physical and mechanical effects in the ultimate protective film. The problem that remains is the selection of that blend of pigments, suspended in a suitably adjusted vehicle (the paint as a whole possessing the necessary physical properties), which will, under known conditions as to exposure and climatic conditions, yield a satisfactory protective film. Only exposure tests can solve this problem."

Influence of Economic Situation on Past Practice.—In the past, most steel structures have been superseded because they were inadequate to meet more modern development and not because the lasting quality of the structure had become impaired. The feeling among engineers in consequence has been that paint materials and the subject of protection were minor considerations, and therefore there has been no ecoonomic demand for improved application or shop practice. Because of the demand for steel construction, engineers generally have devoted their attention to developments in design and the subject of conservation or maintenance of the structure has been allocated as of secondary consideration. This is demonstrated by the fact that many engineers ignore the effect of variations in qualities of materials built into an exposed structure and by the fact that most of the tests on corrosion have seldom been completed or followed up. Some engineers are now taking a more active interest in corrosion because of the present demand for conservation. The cost of steel construction and the realization that these are handicapped under present practice by heavy maintenance charges which, if capitalized, would necessitate a very large investment to provide interest to meet them, are apparently responsible for an economic demand to reduce maintenance costs.

Causes of Corrosion.—Efficient protection of iron and steel structures by paint can be obtained only when the true causes of corrosion are appreciated and effective means taken both in the design and maintenance of a structure to combat these causes. At the present time no absolutely indestructible or permanent protection is known, but by the use of properly selected paints in conjunction with efficient design and application, maintenance work may be reduced to a minimum much below the present average and the structure maintained without appreciable deterioration.

The deterioration of steel structures is caused by electro-chemical action between the steel and the surrounding elements or, what is often overlooked, by similar action between various members or portions of a structure. A brief explanation of such electro-chemical action in its relation to steel might be worded as follows: All ferrous metals when placed in water or in an atmosphere which acts as an electrolyte, or in such conditions of exposure that a film of moisture may condense on them, tend to dissolve. This tendency is governed by impurities, unequal stresses and unhomogeneous nature of the metal in each case, and by the impurities in the liquid or gases is film. Certain points in the metal, which have varying tendencies to go into solution, form electrodes of opposite nature, and corrosion takes place in proportion to the potential difference between these points, governed by the value of the electroylte connecting them. The more concentrated the hydrogen ions in the electrolyte (for instance where acids are present), the higher will be its electric conductivity, and the more rapid, consequently, the corrosion of the positive electrode. It is evident, therefore, that in a fabricated structure this action between points applies not only to each surface in detail but to the whole structure where the sections and members may be of varying composition or subject to intial stresses.

Owing to the process of manufacture by heat, steel plates and shapes are always coated with scale which is the black magnetic oxide of iron. This, though it has at first a metallic blue sheen, is not part of the metal, and as it is electro-negative to the steel or iron, it forms a surface which actively promotes corrosion from the moment it is exposed unprotected to the atmosphere. This corrosion is hastened in proportion to the amount of moisture in the air and any acid present. The mill scale as it corrodes changes into a hydrated red oxide of iron holding 24 per cent of hygroscopic moisture which is never dried out under atmospheric heat conditions, but acts as an eccelerator of further corrosion. As this change takes place the scale increases to more than double its bulk, gradually loosens and flakes off.

Paint applied on top of corroded scale, even though the oil appears to penetrate the scale, will only retard corrosive action but will not neutralize the electro-negative polarity or bond the scale to the underlying metal. The oil cannot displace the moisture already present in the scale, therefore the paint merely acts as a covering under which active corrosion proceeds. The gradually increasing bulk of the scale under this action over-stresses the paint film as it is lifted from the metal, while the iron oxide formed has a tendency, where oil or varnish vehicles are used, to make the paint film brittle, with the result that holes and cracks develop in the film through which moisture penetrates under the paint and corrosion is further promoted. Blue mill scale adheres so firmly to the metal that it can only be removed by means of the sandblast or the pickling process. It is also practically impossible to wholly remove partly corroded scale by wire brushes, scrapers or hammers. Under the best practice for protection this also should be removed by sandblast or pickling process. So long as any mill scale remains on the steel surface, one has a potential corrosive agent under the paint which will become active the moment contact can be established through an electrolyte with the metal. An effort along the lines of improvement is illustrated by the fact that the largest steel fabricating shop in this country has recently installed a pickling plant and is prepared, if customers are willing to pay the cost, to treat steel in this way and in consequence remove the mill scale before the first coat of paint is applied.

Building Up a Protective Paint Film.—It is evident from the explanation of corrosion that the function of paint is to act as a lasting insulator between the electrodes of varying solution tension or electric potential value, and prevent contact between these and the electrolyte. The problem in practice is ont only to obtain this quality, but to combine in the film the following necessary features, the lack of which would result in expensive maintenance:

1. The film must be suited to the exposure to which the structure is subjected in order that moisture or gas acting as an electrolyte may not penetrate the paint and overcome the insulation.

2. The paint must adhere so closely to the surface that in the event of any local damage to the film no source will be established from which corrosion can creep under the paint and in time remove the whole in flakes or sheets.

3. The film must be tough and elastic in order that it may withstand abrasion and in the event of any mill scale under it, resist for the longest period without fracture.

4. The paint must be of such a nature that as it loses its value, due to exposure, and recoating becomes necessary, a suitable surface is left on which to apply maintenance paint so that minimum expense may be involved.

Protection by a single application heavy film paint has been sometimes advocated, but in the first place it is almost impossible to obtain such a paint with toughness penetrating the film as required, combined with adhesive and waterproofing qualities. In the second place, such a film would require to be applied before the steel was fabricated in the structural shops in order to protect the steel before the blue scale became corroded and scaling started, in which case it would probably become damaged during transition through the shops, transportation to the site or during erection of the structure. To arrange for it to be applied in the field after erection of the structure would entail expensive cleaning of the steel under difficult inspection conditions and trouble would certainly arise in the treatment of many inaccessible or intricate built-up sections. Paint makers are constantly experimenting under working conditions at their plants to devlop improvements on the protection of steel, but so far, no single coat paint has been developed that has given satisfactory results combined with practical efficiency.

Units of Built-Up Film.—The practice which has produced most satisfactory results has been when a combined film is built up of two or three units, each one adapted to the specific purpose required of it. The combined film must have integral freedom from impurities such that it will not permit outside elements, or ingredients in its composition in conjunction with outside elements, to form electro-chemical combinations and promote corrosion. This film must have sufficient thickness to insure efficient life as the action of the elements causes gradual oxidation and disintegration.

The first unit of a combined film is the shop coat, the function of which is to prevent the start of electro-chemical action on the surface while the steel is easily accessible and so form a base on which exposure or field coats are placed. As it is the base of all protection, it should receive the most careful consideration. It must dry hard with strong adhesive and anti-corrosive qualities and yet be sufficiently elastic and waterproof to resist damage in the handling of the structure during its transition through the fabricating shops and for a period until the steel is erected, otherwise corrosion of the surfaces is started before the exposure or field coats are applied. It must be a light coat, as otherwise, when used as an assembly paint between surfaces in contact through which hot rivets are driven it is liable to burn out, forming gas pockets and be the cause of loose rivets. It should be easily spread in order that it may be worked into all portions of a built-up section without difficulty by the shop labour.

The second unit in the combined film should be applied on top of the construction or shop coat of paint, after the structure is erected and any abraised portions have been spotted with the shop coat. This paint is required to build up the paint film and form a reservoir life for the exposure paint, also to ensure that the shop paint which has weathered during erection of the structure is reinforced and free from any minute checking, especially if the structure is large and has taken some time to assemble, or where it is composed of light sections the edges of which are difficult to cover with one coat of paint. This paint should be a steel-surface anti-corrosive paint but slightly more elastic than the regular shop paint.

The third unit in the combined film is the one subjected to the exposure and, just as the shop coat is the base on which the paint film is built up and on which depends the success of protection against electro-chemical action on the surface of the steel, so the function of the exposure coat is to protect the shop coat against the various conditions to which the surface is subjected during its exposure.

It is evident that the conditions which govern steel buried in the ground where the paint film is subjected to fairly uniform temperatures without sudden change but constantly to the action of moisture impregnated with mineral salts, etc., are entirely different to the conditions governing exterior atmospheric exposure where the action of the sun and frost, with temperature variations of over one hundred and twenty degrees Fahrenheit and call for altogether different qualities in the exposure paint film.

One of the causes of high maintenance costs in steel structures is the neglect to apply paint on an exposed surface until not only the field coat of paint has lost its vitality, but corrosion has so far attacked the under coating that bare portions of the steel are exposed, and thereafter applying only one coat of field paint. It should be remembered that in many cases the most effective field coat is not a proper shop or steel-surface paint and that it may not stop corrosion spreading under the surface if it is not applied on top of an anti-corrosive paint. If corrosion is far advanced on a structure, at least two coats of paint should be applied after the surfaces have been thoroughly cleaned, and the first of these should be a real anti-corrosive steel-surface paint fulfilling all the requirements of a shop or construction paint.

Points in Use of Paints.—There are one or two essential points in the use of steel paints, however, that should be carefully considered:

1. The manufacturer should always be advised of the exposure to which the paint will be subjected and if possible the nature of the paint already on the surface.

2. Paints containing linseed oil should not be applied on top of asphaltic paint, as action will set up between the paint films and the protective value of both coats will be destroyed.

3. Paints containing linseed oil should not be applied over or under tar paints, as similar action will occur and active corrosion may be immediately promoted.

4. Paints should never be purchased on the basis of price per gallon, as this does not give any comparison of either cost of work or service done. Comparative costs should be based wholly on service records of paint and cost of application per unit of tonnage or area.

Tonnage Covered by One Gallon of Paint.—It may be of use to have the approximate tonnage of various structures which may be covered by one gallon of good paint, (one coat), based on the thickness of sections:

Sections 3/16 to 1/4 in. thick—transmission towers—1½ to 2 tons per Imperial gallon.

Sections ⅜ to ½ in. thick—light mill buildings, highway truss spans—2½ to 3 tons per Imperial gallon.

Section ½ to ¾ in. thick—medium building construction and light railway truss spans—3 to 3½ tons per Imperial gallon.

Sections ¾ to 1 in. thick—heavy building construction and railway girder spans—4 to 5 tons per Imperial gallon.

Use of Lighter Alloys for Structural Work

Abstract of an Address Presented Nov. 2 Before the Toronto Branch of the Engineering Institute of Canada

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It is less than 100 years since Wohler (Gottingen) obtained relatively pure aluminum by the device of heating aluminum chloride with potassium. It was not till 1854 that any appreciable reduction in the cost of manufacturing aluminum occurred. About this time, however, the classical work of St. Claire Deville (Paris) had enabled the price of this metal to be reduced from about $110 to about $6.50 a pound, and by 1892 the development of electrolytic processes for the extraction of aluminum from its oxide had led to a still further reduction in its price. The Heroult-Hall process had made such strides that there was a good supply of pure metal at $1.70 a pound. At the present time 98 to 99 per cent aluminum may be purchased for about 20 ct. a pound.

As would be expected, the alloys of this new metal were the subject of considerable investigation. The ninth report of the Alloys Research Committee to the Institution of the Mechanical Engineers which was presented in January, 1910, may, however, be considered as a milestone on the way of discovery in this connection, since it was to such alloys as were dealt with in this report that Wilm in 1911, added the element magnesium, with the result that light alloys were discovered having the property of hardening, with lapse of time subsequent to their quenching—a characteristic somewhat analogous to that possessed by steel.

It may be of interest to inquire into the economics of certain of the light alloys of aluminum in respect of their use in structural work. These alloys hitherto have been almost entirely employed by the mechanical engineer. They have, on account of those properties later to be considered, proved of special service in the construction of aircraft. But few structures wherein these alloys have played a part have been erected. The reason for this will not be far from sight when the subject has been more fully investigated. However, let it be said at once, that the item of cost per unit weight of metallic aluminum alone appears to the speaker to stand between these alloys and the possibility of their more general adoption by structural engineers.

Basis of Economic Comparison.—Whether it will prove economical to employ the light alloys in the construction of say buildings or of bridges, will depend upon three things —(1) upon the cost per unit weight of the alloy employed, (2) upon its yield point, and (3) upon its specific gravity.

It is obvious that the total cost of any given structure will vary (a) directly as the cost per unit weight of the material forming the structure; (b) inversely as the yield point of the material forming the structure, since, other things being equal, the weight of material required will be less the higher its yield point; and (c) directly as the density of the material forming the structure, since the dead load varies directly as the density of the material forming the structure. If then, C be the total cost of a given structure, c the cost per unit weight of the material forming the structure, Y its yield point and P its density, C varies as c P/Y. Now Y/P may, for convenience, be termed the specific yield point, and may, for like reasons, be given the symbols. Hence C varies as c/s.

If now a given light alloy is to compete successfully with steel, the ratio of its cost per unit weight, c, to its specific yield point s, that is, its ratio c/s, must, other things being equal, be less than the ratio c/s for steel. If for structural steel we assume the cost per pound—not, be it noted, the cost per pound if the steel erected—to be 2 cents, the yield point to be 32,000 lb. per sq. in. and the specific gravity to be 7.85, we have for the c value 2, for s the value 4076 and for the c/s ratio the value 0.00049. If then a given light alloy is to compete successfully with steel its c/s ratio must be equal to or les than 0.00049.

Properties of Duralumin.—Let us now consider how duralumin, the light alloy discovered by Wilm in 1911 which has been referred to above, stands in this respect. Leaving for the moment the question of its cost per unit weight, let us turn our attention to its composition and to its mechanical properties.

Those complex light alloys classified under the name duralumin contain from 3.5 per cent to 4 per cent of copper from 0.5 per cent to 1 per cent maganese and up to 0.5 per cent of magnesium. There are generally present in these alloys small proportions of silicon, an element which has been shown by Rosenhain and his collaborators to exert a most important influence upon certain of the peculiar properties of these alloys.

In the cast state these alloys offer little to surprise in so far as their mechanical properties are concerned. The average tensile strength of the same as cast in sand is but 15,600 lb. per square inch, that of the alloy as cast in chill is 14,200 lb. per square in. Their ductility and the resistance offered to shock is practically nil. Thermal treatment, while it does result in an improvement in their tenacity, has not the least influence upon their ductility and resistance to shock.

The reduction of these alloys in the rolls, or by drawing can be successfully accomplished at temperatures in the vicinity of 450° C. If, however, they be annealed at 450° C. subsequent to casting they can be reduced in the rolls at ordinary temperatures without appreciable difficulty. For sheets of thickness in excess of about ½ in. the maximum reduction in thickness of strip can be thus affected without rupture of the sheets in about 33 1/3 per cent.

The mechanical properties of duralumin sheet such as has first been rolled at room temperature, has then been annealed at 450° C., and has finally been cooled in air, are about as given in Table I.

TABLE I.—MECHANICAL PROPERTIES OF DURALUMIN SHEET.

	Yield point lb. per sq. in.	Maximum tensile stress lb. per sq. in.	Elongation % 1=8(a)½
Longitudinal ..	18,500	46,000	18
Transverse ...	17,100	37,000	10

Here, then, is a material possessed of the tenacity of a normalized mild steel containing about 0.085 per cent of carbon and but little manganese. Its ductility is, however, low in comparison to that of such steel.

Value of Quenching.—If now, such sheet as is referred to above be heated to a temperature of 475° C. and quenched in water at 20° C it is found to have undergone a profound change in constitution. Tests made on the material immediately after quenching show it to have a yield point of 14,200, an ultimate tensile strength of 42,700 lb. per square inch and an elongation of 20 per cent. Apart from the fact that the value of the elastic limit and the maximum stress of the alloy are somewhat less and those for the other constant are somewhat greater no appreciable change can be said to have occurred immediately in the material.

Strength Increase With Seasoning.—With lapse of time, however, a continuous and radical change occurs in the alloy which results in a remarkable rise in its tenacity. Tests made on the last alloy four days subsequent to its quenching showed it to have a yield point of 31,200, a maximum stress of 54,000 lb. per square inch and an elongation of 22 per cent. The material is now possessed of the yield point and of the tenacity of a 0.14 carbon steel (annealed at 866° C., the annealing temperature recommended for this steel by the A.S.T.M.) and a percentage elongation somewhat less than that of the same steel (39.5 per cent in 2 in.).

In this connection may well be recorded the results of tests quoted by Rosenhain, Archbutt and Honson in the last (11th) report of the Alloys Research Committee to the Institution of Mechanical Engineers. Tests were made in 1911 on a duralumin channel with results given in Table II.

TABLE II.—TESTS ON DURALUMIN CHANNEL, 1911.

Yield point lb. per sq. in.	Maximum tensile stress lb. per sq. in.	Elongation % in 3 in.
37,800	59,300	16.6
39,200	61,700	20.3

From the same channel samples were removed for tests in 1921, the results of which were as given in Table III.

TABLE III.—TESTS ON DURALUMIN CHANNEL 10 YEARS OLD.

Yield point lb. per sq. in.	Maximum tensile stress lb. per sq. in.	Elongation % in 3 in.
46,100	64,300	15.3
46,400	62,000	14.7

Here is a material possesed of such tenacity as would make it quite acceptable for service under Structural

Steel Specification of the C.E.S.A. Its ductility, however, is such as to make it doubtful whether it could be successfully employed in place of structural steel in this connection.

Economic Status of Duralumin.—The c/s ratio for this material may now be determined. At the present time, duralumin sheet costs about 30 per cent more than does aluminum sheet, i.e., from 40 to 45c per pound, while duralumin rod may be purchased at about the price of pure metal rod, 30c per pound.

The yield point of duralumin may, we think, quite justly be taken as 40,000 lb. per square inch. Its specific gravity is in the neighborhood of 2.8. Its specific yield point is, therefore, 40,000/2.8=14,300 and the c/s ratio, assuming a price of 35c per pound, will be 35/14,300=0.00245. The c/s ratio for duralumin is, therefore, about 5 times that of our standard steel.

Let it now be noted that the scales have here been slightly weighted in favor of the steel. It is a matter of fact that under the C.E.S.A. specification for structural steel material possessed of a yield point of as little as 27,500 lb. per square inch could pass for service, that is, material such as would have a specific yield point of 3503 and a c/s ratio of 0.00057. And, from what we have seen, an elastic limit of at least 45,000 lb. per square inch may sometimes be expected of duralumin. The c/s ratio of such material would be as low as 0.00218, that is, about 3.82 times that of the steel.

Newer Aluminum Alloys.—Of the light alloys recently investigated, those referred to in the 11th Report of the Alloys Research Committee to the Institution of Mechanical Engineers as alloys A, E, F, G, and Y are of particular importance.

The first of these alloys—alloy A—contained, apart from aluminum, 20 per cent of zinc and 3 per cent of copper. It was possessed of a specific gravity of 3.1. After much experiment it was successfully reduced by hot rolling to rods 1⅝ in. in diameter and less. The tensile tests upon this alloy in the form of rods from ½ to 1⅝ in. in diameter gave yield points from 39,000 to 41,400 lb. per square inch, ultimate tensile strength from 59,100 to 61,400 lb. per square inch, and elongations in 2 in. from 17 to 21 per cent. The safe range of alternating stress (Wohler test) for this alloy at 20° C. is 19,509 lb. per square inch.

Alloy A is possessed of a tensile strength in the hot-rolled state equal to that of a 0.18 carbon steel annealed at 858° C., the annealing temperature recommended for this sheet by the A.S.T.M. It is a somewhat cheaper alloy than is duralumin and should cost about 28c per pound. Assuming the material to have a specific yield point of 39,000 lb. per square inch its c/s ratio would be 0.00222, that is, about 4.5 times that of our standard steel.

Alloy E.—The second of these alloys—alloy E—contained, apart from aluminum, 20 per cent of zinc, 2.5 per cent of copper and 0.5 per cent each of magnesium and manganese and proportions of iron and silicon not exceeding 0.2 per cent. Hot rolled rod ⅞ in. in diameter gave a yield point of 52,100 lb. per square inch, an ultimate tensile strength of 66,500 lb. per square inch, and an elongation in 2 in. of 15 per cent. The same rod quenched from 400° C. and aged for 5 days gave 48,400 lb. per square inch, 91,000 lb. per square inch and 9 per cent respectively. In this case the safe range of alternating stress is 21,700 lb. per square inch.

Alloy E. is possessed of a mean c/s ratio of about 0.00174, a ratio which is about 3.6 times that of our standard steel.

Alloys F and G.—The third and fourth of these complex alloys—alloys F and G—were of the analysis given in Table IV.

TABLE IV.—ANALYSES OF ALLOYS F AND G.

	F	G
Copper	2.50	2.50
Zinc	20.00	18.00
Magnesium	0.50	0.35
Manganese	0.50	0.35
Silicon	0.75	0.80
Aluminum	remainder	remainder

Tensile tests made on the former alloy—alloy F—gave for a ⅞-in. hot rolled rod quenched from 400° C. and aged for 5 days a yield point of 56,700 lb. per square inch, an ultimate tensile strength of 80,600 lb. per square inch, and an elongation in 2 in. of 16 per cent. In the form of 0.04 to 0.05-in. sheet similarly treated, the results were 68,100 lb. per square inch, 79,200 lb. per square inch and 19 per cent respectively.

For this alloy in the first condition (a) the c/s ratio is as low as 0.00153, while in the second state (b) the ratio is as low as 0.00127. The ratio is in the first instance about 3.13 times and in the second case about 2.59 times that of our standard steel.

Alloy G on test gives a yield point of 68,500 lb. per square inch, an ultimate strength of 77,500 lb. per square inch and an elongation of 19 per cent. In this case the alloy was tested in the form of sheet 0.04-0.05 in. in thickness which had been quenched and aged. The c/s ratio for this alloy is 0.00127, practically the same as the last, and is about 2.59 times that of our standard steel.

Alloy Y.—The mechanical properties of the last alloy we shall consider in this connection—alloy Y—have been referred to by Rosenhain, Archbutt and Hanson in the following terms: "The material shows an ultimate stress of 26 to 27 (long) tons per square inch, with 16 to 18 per cent extension on 2 in. in the case of sheet 0.5 in. thick; thinner sheet 0.18 in. thick shows tensile strength of 27 to 28 (long) tons per square inch with elongations of 15 to 17 per cent on 2 in." Experiments by these observers on samples of this alloy prepared by cold rolling at the Royal Aircraft Establishment and quenched subsequent to deformation from a temperature of 520° C. showed the treated alloy to be possessed of a yield point of—47,000 lb. per square inch, an ultimate tensile strength of 62,700 lb. per square inch and an elongation in 2 in. of 18 per cent. Both the cost per unit weight and the density of this alloy approach closely to those of duralumin. Assuming 47,000 lb. per square inch to be the yield point, 2.8 to be the specific gravity and 35c per pound to be the cost per unit weight of the Y alloy we obtain as the c/s ratio the value of 0.00201—a c/s ratio 4.16 times that of our standard steel.

Cost Factor a Handicap.—Now it will be noted (1) that the yield points of all the alloys we have considered are such as would allow of their acceptance for service under the C.E.S.A. specification for steel for bridge construction, (2) that their tenacities are such as would permit of similar treatment, but (3) that their ductilities are in most cases somewhat less than those accustomed to the use of structural steel would feel justified in allowing to pass unnoticed. To this aspect of the situation we will refer later. For the present, it may be emphasized that, but for the high cost of these alloys, their immediate use might be expedient in certain instances. The cost factor is that which in the c/s ratio weighs so heavily against these light materials. Now we have dealt in terms of the delivery costs of these light alloys, and of steel, not in terms of the cost of these same materials in place in the finished structure. When consideration is taken of the lesser cost of transportation, when note is made of the lighter machinery that would be required to cope with the problem of erection, when it is considered that a brisk demand for these materials might result in a material reduction of their price it might have an exactly opposite effect at first—and, lastly, when it is remembered that both the methods of manufacture of these alloys and the alloys themselves are subject to improvement, there is good reason, I believe, for the opinion that their use in construction is not likely to be delayed long.

Low Ductility Problem.—It should be remembered, in connection with the matter of ductility, that, while a given minimum value for the percentage elongation of steel may serve as a criterion of the toughness of that product, it does not of necessity mean that a similar value for this factor in the case of another alloy will serve the same purpose in identically the same way. It has been clearly demonstrated that while notch toughness may serve to distinguish between the good and the bad of a given batch of material of about the same composition, it cannot be relied upon to determine the relative merits of material of totally different character and composition. The same argument may be applied in some measure to the question of ductility. However, a point in this connection worthy of note is that the safe range of stress reversal for these alloys is only about half that of structural steel.

Economic Comparison of Alloys.—In Table V are collected the results of the determination of the c/s ratio for these light alloys, together with the ratio of their c/s value to that of steel with a yield point of 32,000 lb. per square inch and the approximate price of the alloys per pound.

TABLE V.—ECONOMIC COMPARISON OF ALUMINUM ALLOYS WITH STEEL.

	c/s	Ratio of c/s value of alloy to c/s value for steel	Approximate price per lb. cents
Steel	0.00049	1	2
Duralumin .	0.00245	5.0	35
Alloy A	0.00222	4.5	28
Alloy E....	0.00174	3.6	28
Alloy F (a).	0.00153	3.1	28
(b)	0.00127	2.6	28
Alloy G	0.00127	2.6	28
Alloy Y	0.00201	4.1	35

A brief consideration of the results contained in this table will serve to show that, if these alloys are to compete successfully with steel they must be reduced in price to the values quoted in Table VI.

TABLE VI.—APPROXIMATE PRICES OF ALLOYS NECESSARY FOR ECONOMIC COMPETITION WITH STEEL.

	Price per lb.
Steel	2
Duralumin	7
Alloy A	6
Alloy E	8
Alloy F (a)	9
(b)	11
Alloy G	11
Alloy Y	8

Relative Erection Costs.—Here again let it be observed that in arriving at these values it has been assumed that the cost per unit weight of these materials in place within a given structure is a constant multiple of the cost per unit weight of these materials at their place of origin. In order to make plain the difference in the cost of erection that is likely to ensue as a result of the employment of these light alloys it is only necessary that attention be called to the relative weights of rolled sections of the same area.

A moment's thought will make it obvious that in the erection of certain structures the use of steam or electrically-driven lifting machinery could be entirely eliminated were the light alloys employed in place of steel, not that this means of necessity a lessening of the total cost of erection. Nevertheless, it is possible that the freight charges coincident with the transportation of lifting machinery could in such extreme cases thus be entirely eliminated. In any case, however, such mechanical devices as are required in the erection of steel structures could be replaced by others of much lighter type here the light alloys are employed.

Shop Costs.—Yet another point worthy of consideration here is the cost of shopwork that is likely to ensue in connection with structures made of these light alloys. The specific yield points of the light alloys are considerably in excess of those ever likely to be obtained in such alloy steels as could economically be employed in construction. Consider, for example, the nickel steel occasionally employed in bridge construction. This has a yield point of about 60,000 lb. per square inch (Waddell), hence a specific yield point of about 66,000/7.7 =7800, almost half that of duralumin, the light alloy of those we have considered possessed of the least value for this factor. The machine-ability of nickel steel, however, is considerably less than is that of the light alloys, which are relatively easy to ream or drill. Hence, those extra expenses attached to the use of the special steels on account of the concurrent increase in their resistance to penetration and their tenacity, are not likely to be experienced when the light alloys are in employment.

Transportation Costs.—Finally, the cost of freight and of transportation, especially in a country of vast distances such as in Canada, is of immense importance. To the cost of structural materials per unit weight at their place of origin there may be added, under certain circumstances, a freight charge of as much as 5c per pound. Such freight charges may sometimes become disproportionate, even prohibitive, items of expense. If, therefore, these charges could by the use of light alloys be reduced to practically a third (to something at any rate less than 2.95/7.85=1/2.66 of their amount the use of such alloys might be abundantly justified in certain situations, in outposts of the Dominion where the erection of buildings or other structures, which now would be made of steel, is essential for the successful issue of all manner of engineering enterprise. The possibility of the elimination of freight charges on plant required for erection has been referred to already.

It might well be that in certain circumstances these three items of expense—erection costs, shop costs and freight cost might sufficiently reduce the total cost of erecting a structure in a light alloy, even at present prices, to enable its use in place of steel to be seriously considered.

Corrosion.—The question of corrosion in this connection is a vital one no more vital, however, than is that of the corrosion of steel. The protection of aluminum can be accomplished as can that of its alloys. The use of these alloys in situations where they are likely to be brought into contact with sea water could not, it is thought, be considered at present. Much more work requires to be done before a definite statement as to the reliability of protected light alloy structures under these conditions could be made.

Forms for Recording Pile Driving Data

Methods of Railroads in Recording and Reporting on Pile Driving Operations

The importance of making and filing complete and dependable notes of piles, piledriving and soil explorations cannot be overestimated. This particularly in the case of the railroads as has been brought home to them in the work of preparing valuations of their properties for the Interstate Commerce Commission. These data will be found valuable in estimating and ordering material for emergency replacements as in the case of bridges destroyed by fire, washouts and wrecks. Other occasions for their use arise when structures are to be enlarged in extent or increased in height and when it must be determined whether additional piles will be needed and if so the number and length required. Some useful suggestions on compiling and preserving information of this kind are given by the American Railway Bridge and Building Association Committee on pile driving and pile driving records in its report submitted Oct. 17 at the 32nd annual convention of the association. The notes following are taken from the report:

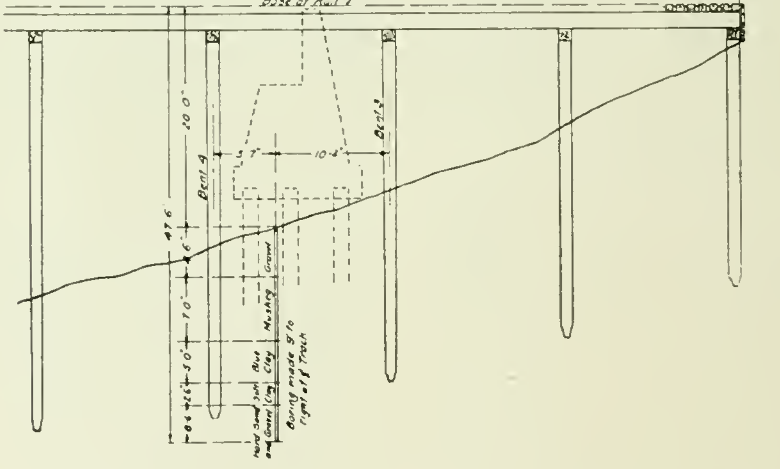


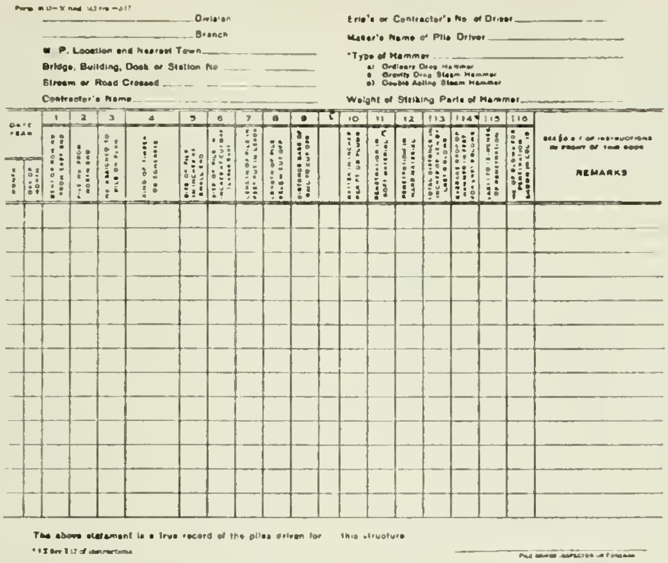
Fig. 1.—Notes of Soil Exploration Made in Survey for Bridge by A. B. &

The results of soil explorations should be not only entered in the field books but also placed upon the piling plan for the information of the inspector and pile driver foreman. Fig. 1 shows the notes of soil explorations placed on the survey plan for a new structure.

The practice of the various railroads regarding pile driving records discloses a number of methods of recording and reporting data of pile driving operations. Some railroads use a field book into which the original notes are placed, and from there, office records are made either in tabular form or on foundation or special pile record plans. Other roads have forms 8½ in. by 11 in. or larger on which daily or job reports of pile driving are made, to be mailed in to headquarters. Cost data are usually given on separate reports or are made up in the office from time sheets. The committee feels that the ideal place for original notes is in a field book. Headings can be printed or placed on each sheet with a rubber stamp or even lettered on according to instructions. From the note book record the other reports can be made up.

Standardizing Pile Driving Records.—There is considerable opportunity for standardizing the important items in pile driving records. The heading should contain reference to the location of the work on line or branch, date, contractor, pile driver number, and kind and weight of hammer. In case of the gravity drop steam hammer the make and number should be given, together with the number of strokes per minute, the height of fall and weight of entire hammer and striking part separately. If a double-acting steam hammer is used, it is necessary also to record the diameter of the piston.

In the body of the report some put in a date column so as to provide a continuous pile record and to give the opportunity to record the date each pile is driven. The best practice is to number the bents in the direction of the mile posts and the piles from left to right. For piers and other foundations a sketch or pile plan will indicate the system of numbering. The kind of timber or



Form # D-X new 143 rev -417

______ Division
______ Branch
M. P. Location and Nearest Town ______
Bridge, Building, Dock or Station No ______
Stream or Road Crossed ______
Contractor's Name ______

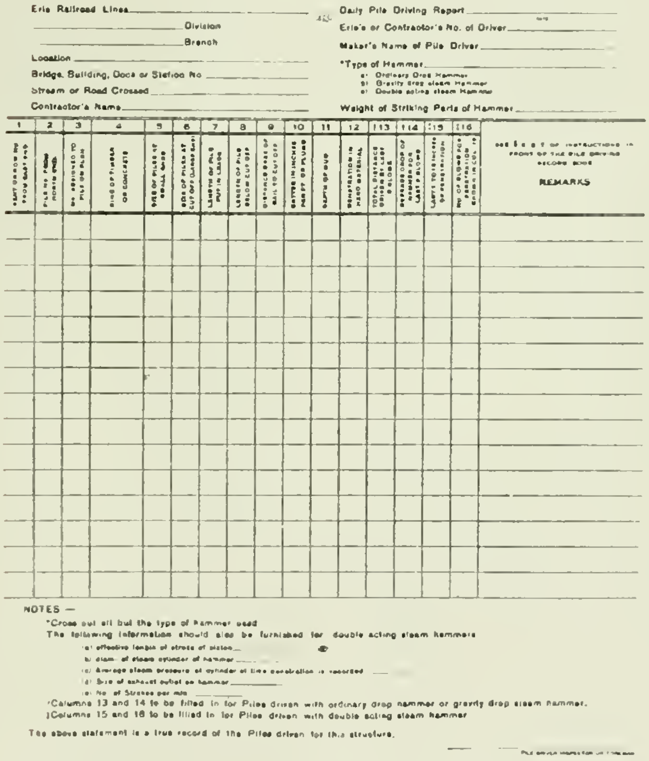
Erie's or Contractor's No. of Driver ______
Maker's Name of Pile Driver ______
*Type of Hammer ______
a) Ordinary Drop Hammer
b) Gravity Drop Steam Hammer
c) Double Acting Steam Hammer
Weight of Striking Parts of Hammer ______

Date Year		1	2	3	4	5	6	7	8	9		10	11	12	†13	†14	‡15	‡16	REMARKS

The above statement is a true record of the piles driven for this structure

*† ‡ See ¶ 12 of instructions

Fig. 2.—Pile Driving Record Blank of Erie R. R.



Erie Railroad Lines ______
______ Division
______ Branch
Location ______
Bridge, Building, Dock or Station No ______
Stream or Road Crossed ______
Contractor's Name ______

Daily Pile Driving Report ______
Erie's or Contractor's No. of Driver ______
Maker's Name of Pile Driver ______
*Type of Hammer ______
a) Ordinary Drop Hammer
b) Gravity drop steam Hammer
c) Double acting steam Hammer
Weight of Striking Parts of Hammer ______

1	2	3	4	5	6	7	8	9	10	11	12	†13	†14	‡15	‡16	REMARKS

NOTES —
*Cross out all but the type of hammer used
The following information should also be furnished for double acting steam hammers
(a) effective length of stroke of piston ______
(b) diam. of steam cylinder of hammer ______
(c) Average steam pressure at cylinder at time penetration is recorded ______
(d) Size of exhaust outlet on hammer ______
(e) No. of Strokes per min ______
†Columns 13 and 14 to be filled in for Piles driven with ordinary drop hammer or gravity drop steam hammer.
‡Columns 15 and 16 to be filled in for Piles driven with double acting steam hammer

The above statement is a true record of the Piles driven for this structure.

Fig. 3.—Daily Pile Driving Record Form of Erie R. R.

concrete in the pile should be noted. In the case of timber piles the diameter of tip and butt should be given, and in the case of concrete, the date of manufacture and the name of the manufacturer. Next should be recorded the length of pile in the leads, the length below cut-off, and the distance from base of rail, top of pier or other reference to the cut-off.

Recording Penetration.—The next group of data to be recorded is that regarding the penetration. It is well to record the total penetration and the amount of penetration in the soft and hard materials separately. Some roads record the rate of penetration per blow at the beginning, average, and final portion of the driving. To determine the bearing power of the pile it is essential to give the average drop of hammer for the last few blows and the average penetration in inches of the pile under these blows. With the steam hammer it is more convenient to record the number of blows used to secure the penetration of the last 6 in. or other designated distance, or to give the distance penetrated for the last 10 or 20 blows. In the case of the double-acting steam hammer it is essential to give the average pressure in the cylinder at the time the final penetration is observed. From these data it is possible to compute the safe load for each pile by using an appropriate formula.

A column for remarks should be provided into which can be placed notes regarding the matter of piles, broken piles, whether rings or shoes were placed on piles and other information that may be desirable. Many roads record the total number of blows for driving the pile. It is also desirable to give the original length of the pile used, where a pile is cut off before being put in the leads, provided the part cut off is wasted and not driven as another pile.

Test Pile Records.—For the record of test piles it is necessary to give the rate of penetration for each foot of the driving and as much information as is possible regarding the kind of soil, along with the data of ordinary driving as given above. It is especially important to get the complete record very accurately on the driving of test piles. The record of soil exploration by borings should show the location of the test and the distance from base of rail or other definite reference point to each kind of soil. Note should be made of the compactness and moisture content of the soils encountered.

The records referred to in the last few paragraphs have been largely for the original field book notes. Where it is desirable to get the report of the work to the office before the field book can be turned in, report blanks can be made up similar in form to the headings for the field book pages. The data may then be copied from the note book and either daily progress or job reports sent to headquarters as required. All reports should be signed and dated.

Forms.—A number of forms are given as a part of this report. The Erie R. R. has a system of report forms that seems to be very complete. The original record goes into a note book with pages 4 in. by 7 in., as shown in Fig. 2, and a daily pile driving report made on a similar sheet of letter size shown in Fig. 3.

The job report used by the Soo Line and shown in Fig. 4 has some unique features. Each vertical column represents a bent of the trestle. The Central Canada Railway and the Great Northern Railway have good pile driving reports as illustrated in Figs. 5 and 6. These last two are on letter size sheets while the Soo report is on a sheet 8½ by 14 in. Figure 7 illustrates a very complete form for a record of test piling driven used by the Illinois Central Railway. This form is white-printed on letter size sheets.

While the committee does not desire to recommend special forms for pile driving records it does commend for consideration forms similar to those in use by the Erie. A slight modification to fit local conditions would make these forms suitable for almost any railroad.

Traffic on Montana Highways.—Traffic counts made in the eastern half of Montana during the months of July, August, September and October at 60 observation posts indicated an average daily travel of 185 vehicles. Of the vehicles 150 were automobiles or about 81 percent, 16 were trucks or about 9 percent, 18 were wagons comprising a little over 9 percent and less than 1 percent were motor cycles. Of the trucks but 3 percent were classed as heavy trucks the remaining 6 percent being classed as light.

Meeting of Slate Industry.—The slate industry will hold meetings in New York at the Commodore Hotel Jan. 22nd and 23rd, under the auspices of the National Slate Association. Operators of quarries producing slate, representatives of mills and plants manufacturing slate products, distributors, dealers, jobbers, roofers, and setters of slate, and anyone from any branch of the slate industry is welcome.

Preservation of Decaying Wood Roofs

Methods Employed and Economic Considerations in Prolonging Useful Life of Roofs of Manufacturing Buildings Described in Paper Presented Sept. 26 at Springfield Regional Meeting of American Society of Mechanical Engineers.

By WENDELL S. BROWN,
Engineer, F. P. Sheldon & Son, Providence, R. I.

Rapid development in industry, like the accelerated progress of civilization, is often and perhaps inevitably accompanied by certain afflictions and disorders. And in the last quarter century one of the disturbing conditions which has arisen and which is demanding increasing attention in certain sections of the industrial world has been the serious decay of wood roofs.

Now a roof is a cover of a building, according to one dictionary definition. But unfortunately, since the advent, in buildings of home-made weather, either in the form of artificially high or naturally high relative humidities —due to some necessary process—a roof must have other attributes than covering only, if it is to act as a real shelter. For, under certain conditions instead of constituting a protection, the reverse is true, and the roof becomes a positive source of trouble. This happens when the formation of condensation (commonly called sweating) on the ceiling is so rapid as to cause dripping into the room below, with consequent annoyance to the occupants and often serious damage to machinery, building, and materials in process.

Happily, it is a comparatively simple matter, by adopting suitable insulation, to prevent the formation of condensation on, and dripping from, the under surface of the roof, for any usual condition encountered. That is, theory and laboratory tests, authenticated by actual installation, have provided accurate methods for rationally designing many different types of roofs to meet varying requirements as to relative humidity and temperature carried in the room below.

Why the Wood Roofs Rot.—But with respect to wood roofs, prevention of visible condensation is only part of the story, for the reason that cracks between the plank afford a more or less direct channel by which warm, moist air from the room below reaches the roofing paper, which latter is practically at the temperature of the outside air. If this temperature is below the dewpoint of the said contacting room air, precipitation of moisture or condensation results; which means nothing more or less than that the first ply of roofing paper and the top of the wood roof itself are saturated with water during the greater part of the heating season in temperature or colder climates. Laboratory tests and the experience of those who have removed old mill roofs bear this out.

In fact, this rot-inducing feature is the outstanding bugbear and cause of excessive mortality in wood roofs of those manufacturing buildings—such as textile mills, finishing plants, paper mills and food factories—which utilize or by nature house high relative humidities. The damage is enormous—greater than generally realized—amounting to hundreds of thousands of dollars annually in building material alone, besides occasioning often more serious losses in production and general derangement. Many such unenviable records exhibit useful roof lives as short as three years, with a possible average of ten years and a maximum of twenty-five years, depending upon the severity of atmospheric conditions within and without the building, and the species and quality of lumber used.

Notwithstanding the subject under consideration is the preservation of old wood roofs, it would be remiss not to admit that some of them are not worth saving. The correct determination of whether or not a roof is worth saving lies in a full consideration of the problem from a purely utilitarian viewpoint, and the paper aims to indicate general principles by which this often debatable question may be settled, and also to describe one method by which the desired result has apparently been attained.

Where the Decay Starts.—Ordinarily, decay in roof plank starts at the top surface, especially if the first ply of paper is dry sheathing not mopped down. Sometimes, however, infection seems to get a foothold first just above the tongue and groove or spline and progresses more rapidly within the central portion of the plank lying between the two extremes of moisture.

In sawtooth buildings, valley plank usually decay first, this being generally traceable to one or more of the following contributory causes:

(a) Since sawtooth lighting areas ordinarily face approximately north, the valleys are considerably shaded by adjacent sawteeth, which latter intercept the warming effect of the direct solar rays when the sun is at low altitude during the heating season.

(b) Often heating coils are located solely under the glass or at some distance up the wooden back of the sawtooth, leaving the valley portion chilled, and subject, therefore, to excessive condensation.

(c) There is a tendency for moisture or condensation to drain toward the low point of the roof.

An indication of the comparative extent to which rotting has progressed in various portions of a roof may often be had from the brown extractive matter deposited in rusty streaks on rafters and plank. Decay is usually greatest in plank and beams at bearings because, due to the additional insulating properties of the supporting members, the locus of condensation dips as indicated in Fig. 1. Tops of roof rafters and girders rot first—usually for the same reason; and other conditions being equal, decay is more active in the vicinity of ventilators, cold conductor pipes, etc.

But the quality of lumber as well as species or variety is also a vital factor in its longevity, and variations in the former often tend to upset too close generalizations concerning the placement of decay. For instance, three years ago two bays of roof plank and one roof rafter in a Rhode Island weave shed were replaced with entirely new but unsuitable material having a high percentage of sap wood. The plank is already more than one-half rotten and is in a worse condition than the remainder of the roof which is 13 years old.

Methods Employed in Preserving Wood Roofs.—Taking up the question of treatment, there seems to be no practicable means of preventing exposure to infection, or of eliminating rot-inducing conditions, as far as temperature alone is concerned.

For new wood roofs antiseptic treatment is possible, and several processes, such as creosoting and kyanizing, may be adopted for the preservation of plank. One creosoting concern has recently introduced a priming paint and claims that it is not penetrable by creosote, thus making possible the application of white ceiling paint directly without sheathing. Girders and beams may be made of steel, but if untreated timber is used the upper edges of beams may be chamfered and covered with a layer of waterproof paper, as shown in Fig. 2. Chamfering tends to raise the locus of condensation, and the paper still further assists in keeping the top of the beams dry.

In the case of existing roofs the treatment must of necessity be ameliorative rather than preventive or curative; and it should be clearly understood that the term "preservation" is meant to indicate merely the economic postponement of ultimate roof renewal and not the attainment of permanency. Briefly, the treatment consists in removing from the fungus its water supply by preventing condensation so far as is practicable. And condensation is decreased by insulating the outer roof surface, the extent of inhibition depending upon the amount of insulation.

There are certain inherent limitations to this treatment which prevent the full attainment either of water-supply removal or of sterilization. First, it is impracticable on account of excessive initial expense to lay enough insulation to wholly prevent condensation within the roof plank even in moderately cold winter weather. Second, certain fungi are suspected of having a faculty—once they are well developed—of manufacturing water to a limited extent through a decomposition of the wood structure itself, provided said decay is deep seated and protected from too rapid evaporation. That is, water in its liquid state is not absolutely necessary for their maintenance. The important characteristic of this treatment is therefore a retarding action accomplished by making the environment as unfavorable as practicable.

Application of Top Insulation.—Top insulation has the effect of moving the plane or locus of condensation for any given set of atmospheric conditions nearer the outer surface of the plank than before, and in mild weather of eliminating it entirely. In other words, the rate of condensation is reduced, as is also its duration, resulting in checking inroads of disease already established, and also in lessening the susceptibility of timber to further infection.

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*"Locus of Condensation" may be defined as a plane whose temperature equals the dewpoint temperature of the contacting room air. Below this plane no condensation takes place; above it, condensation occurs with increasing activity as the top surface of the roof is approached.

Insulation should be in sufficient amount to entirely prevent condensation on the under side of the roof in most severe weather, and if wood, should itself be antiseptically treated. Creosoted yellow-pine boarding nailed to furring strips has been found to be an economical type of insulation. Cheap, open-grained lumber, preferably sap wood, should be used, since it readily absorbs the necessary amount of wood preservative. By laying it over furring strips, additional and especially effective and inexpensive insulation in the form of an air space is obtained. This type of insulation also adds materially to the strength of the roof plank; in fact, it may be made thick enough to support the old plank if the latter have become seriously weakened, and the importance of not interrupting production is paramount. The old plank, where dangerously decayed, would would then be spiked to the new plank from below.

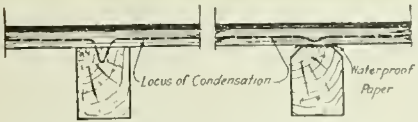

Fig. 1. Fig. 2.

Fig. 1 shows how locus of condensation dips over a beam or rafters. Fig. 2 shows how locus of condensation may be raised by chamfering corners of beam or rafter.

In order to prevent entrance into the new insulating air space of warm, humid air from the room below (and therefore condensation which would otherwise occur within the upper insulating deck and would drip upon the lower untreated plank), it is necessary to have a waterproof membrane between the old roof and the new insulation. The old roofing paper may be left intact and used for this purpose, if practical. On one large weave shed the new insulation was laid directly on the tar-and-gravel roof without removal of gravel, except what could be easily brushed off. If considerable structural renewal becomes necessary, however, it will generally be found advisable to remove the roofing paper entirely, and after necessary replacements have been made, to lay down a two-ply roof over the same before applying the insulation.

An economic consideration of the question invariably shows that the additional insulation saves enough heat to help very materially in meeting fixed charges on the initial cost of installation. This is illustrated later. Furthermore, dripping from the ceiling, which may have been experienced previously, will be stopped.

Sometimes it is advisable to rearrange the heating system so as to obtain a more uniform distribution. In sawtooth buildings a portion of the heating surface should be placed under the plank and a portion under the glass, the object being to obtain a balance (that is, as little circulation of air as possible directly under the sawteeth) and thus maintain a uniform and somewhat higher temperature here, without, however, increasing the room temperature on the working plane. The effect is to decrease still further the rate of condensation within the old roof and the number of days of its occurrence during the year.

Method of Insulating Sawtooth Weave Shed.—The most recent installation with which the author is familiar was completed a month ago under the direction of F. P. Sheldon & Son, Engineers and Architects, with which firm he is connected. The building is a sawtooth weave shed having a projected roof area of 116,000 sq. ft.

The weave shed is now 23 years old, and during the past ten years considerable portions of the roof have been replaced. For humidity, during approximately the first twenty years, it depended upon the admission of moist basement air through belt holes in the floor at each individual loom, the basement being traversed by a canal and containing more or less standing water. Recently, mechanical humidifiers were installed with the intention of maintaining a more constant relative humidity (approximately 75 per cent) than was before possible. The humidifier installation probably has accelerated roof decay somewhat, but, on the other hand, the basement may now be properly ventilated, and the present ravages of decay in floor plank, beams and columns prevented, or at least materially retarded.

Sixty per cent of the roof plank was so rotted as to need renewal. Two per cent of the 6-in. by 12-in. yellow pine rafters, and 25 per cent of the 11-in. by 14-in. yellow pine girders were replaced for the same reason. The good condition of the rafters is worth noting and is doubtless due in part to their narrowness, which tends to prevent any marked dip in the locus of condensation—see Fig. 2.

The technique in this particular instance was briefly as follows: The insulation consisted of ⅞-in. square-edged, creosoted yellow pine boarding nailed on ⅞-in. creosoted furring pieces resulting in a ⅞-in. air space between the old roof and the new boards. The lumber was treated on the job by the hot-dip process, being unloaded direct from the cars to a storage pile within 40 ft. of the creosoting tank, which latter was of steel, 20 ft. long, 7 ft. wide and 5 ft. deep, and had ample capacity for 3,000 ft. B. M. of lumber used daily. Boards were struck with 6-ft. pieces every six boards and were divided into two sections for a given charge, each section fastened with a cable sling. An A-frame derrick (Fig. 3) made of two 50-ft. telegraph poles was used for lifting the sections into the tank. It also served in removing batches from the tank and hoisting them to the weave-shed roof. Heavy timbers were used to ballast the lumber being treated, and these were taken to and from the tank on a carriage moving on rollers, and were lifted from it by the derrick. A batch, after being lifted out of the hot creosote, was held over the tank and allowed to drain for three or four minutes. It was then hoisted to the roof, after which practically no more dripping occurred; the partial vacuum set up by the air and steam in wood cells, cooling, contracting, and, therefore, sucking in the excess surface oil.

The creosote oil used on the job was furnished in a tank car placed on a siding some 300 ft. from and considerably above the creosoting tank, thus allowing a gravity flow in the pipe line connecting the two. Make-up oil was added each time a batch was removed, except that toward the end of the creosoting process, after all the oil had been placed in the tank, the amount of lumber per batch had to be gradually reduced. During treatment the oil was held at a temperature of about 230° F. by means of high-pressure-steam coils having a total heating surface of 270 sq. ft., placed in the bottom of the tank.

The use of wet or unseasoned wood was apparently not detrimental, except for the fact that a longer treatment was necessary in order to insure thorough penetration by first boiling out the entrained water.

The creosote oil used was a modification of Grade 1, American Railway Association Specification, having a specific gravity at 59° F. of at least 1.08, and giving, when distilled, no distillate below 392° F., not more than 1 per cent below 410° F., and not more than 10 per cent below 455° F.

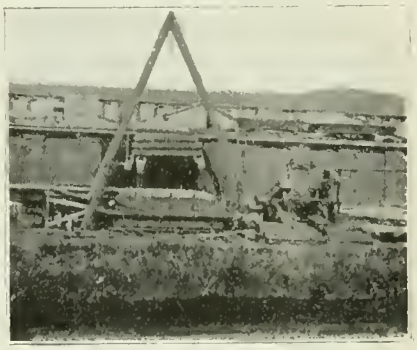
Fig. 3—Derrick and Creosoting Tank.

The penetration was quite thorough, the amount of oil used averaging 9.4 lb. per cu. ft. for a 20-hour treatment. The creosote cost $0.29 per gal. delivered, which, reduced to a board-measure basis, added $0.022 to the unit lumber cost of $0.03, and made a total of $0.06 per board foot for treated boards—labor and overhead for treatment included, but not laying. The labor of laying on roof amounted to about $0.02 per ft. B. M.

Where plank were rotted at bearings, but fairly sound elsewhere, new bearing strips were spiked to each side of the rafter for necessary support.

Not more than one sawtooth for half its length was opened up at any one time, with consequent interruption to only that machinery under this particular section. This usually amounted to less than 80 looms for a period not over nine or ten hours.

Economic Considerations in Prolonging the Useful Life of Repaired Roofs.—Consideration of the problem from the standpoint of economics shows, for this particular building, if the given insulation prolongs the useful roof life no more than five years, that it was warranted and preferable to an entirely new durable roof. Each additional year of life is therefore a net gain, as is also the very real and important (but in this case uncapitalized) saving due to substantially postponing the period in which greater interruption to manufacturing, incident with entirely new roof construction, would occur. The solution was based on the following approximate assumptions made after the necessary study of existing conditions:

1. Regardless of building decay, the felt-and-slag roof, on account of its age and condition, would have required replacement within one year at an estimated cost of $17,000.

2. If decayed members in need of immediate renewal were to be merely replaced by new, without the insulation feature, it was estimated that

equal replacements would again be necessary within 15 years.

Problem: Determine the minimum number of years by which the given insulation must prolong the useful life of the repaired roof in order to prove a financially sound investment, and preferable at this time to an entirely new durable roof.

(a) The cost of the project was approximately as follows:

Insulation, i. e., creosoted plank in place, including extra two-ply waterproof membrane $18,000
Felt and slag roofing 17,000
Necessary renewals of plank, rafters and girders, removal of old roofing, painting, etc........... 28,000
Total $63,000

(b) The minimum cost of an entirely new and durable treated wood roof on yellow pine rafters and steel girders, including painting, complete erection, etc., was estimated at $110,000.

Working out several trial examples, it is found that the said insulation in order to be justified should add at least five years to the useful roof life. Sample computations follow:

(1) The approximate 20-year cost of the repaired roof with insulation (that is, the cost over its augmented useful life of 15 + 5 = 20 years) may be calculated as follows:

Initial cost (wholly depreciated)..$ 63,000
Yearly interest at 6% = $3,780 having a value in 20 years if compounded annually at 6 per cent of 139,000
$202,000
150 tons of coal saved annually at $7 per ton = $1,050, having a value in 20 years if compounded annually at 6 per cent of....... 39,000
Total 20-year cost..............$163,000

It is worthy of note that the insulation saves annually in coal 1,050/18,000 or 6 per cent gross of its cost and vitally affects the computations by reducing the number of years by which the said insulation must lengthen the roof life in order to be justified.

(2) The approximate comparative 20-year cost of repaired roof without insulation is obtained as follows:

Cost of repairs good for 15 years and then wholly depreciated. $17,000 for roofing plus $28,000 for replacements [see (a) above] $45,000
Yearly interest at 6 per cent = $2,700, having a value in 20 years if compounded annually at 6 per cent of..................... 99,000
Cost of equal repairs 15 years hence (probably reduced to $30,000), depreciation at 5/15....... 10,000
Yearly interest at 6 per cent = $1,800, having a value in 5 years if compounded annually at 6 per cent of 10,000
No coal saved ....
Total 20-year cost..............$164,000

(3 The approximate comparative 20-year cost of a new and durable roof having an assumed life of forty years is obtained as follows:

Initial cost, $110,000, depreciation at 20/40 ....$ 55,000
Yearly interest at 6 per cent = $6,600, having a value in 20 years if compounded annually at 6 per cent of................ 242,000
$297,000
100 tons of coal saved annually at $7 per ton = $700, having a value in 20 years if compounded annually at 6 per cent of 26,000
Total 20-year cost..............$271,000

Conclusion.—While it is realized that the foregoing assumptions concerning future prices are conjectural, there is apparently ample margin in the result to show the described treatment to be, in this case, an economical procedure. This factor is especially emphasized when the avoidance of serious interruption to production, which would have attended entirely new construction, is considered; as well as the fact that dripping from the ceiling, which occurred previously during severe winter weather, is prevented.

Several other decayed wood roofs have been similarly insulated within the past three or four years with apparently beneficial results, so that this treatment has passed beyond the purely theoretical or experimental stage.

It is easy for an engineer to recommend sweepingly entire roof renewal with more permanent material, such as concrete, treated plank, redwood, etc., as the only real satisfactory solution of a given problem, but the correct answer is ordinarily determined only after careful analysis and evaluating and balancing every factor pertaining to each individual case.

Index Numbers of Wholesale Prices January, 1913, to November, 1922

The accompanying tabulation shows the revised index numbers of wholesale prices by groups of commodities as computed by the U. S. Bureau of Labor Statistics.

The group of miscellaneous commodities includes such important articles as leather, cottonseed meal, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, starch, tobacco, Manila hemp, sisal and wood pulp. The commodities, composing the other groups, are as indicated by the titles.

The new index numbers and the following explanations, are from Bureau of Labor Statistics, Form 1531:

The weighing of the process used in constructing the index numbers for the different groups of commodities by the new 1919 census figures of production, instead of the 1909 data used in preceding reports, conforms to the plan contemplated by the Bureau at the inception of its weighted index number system in 1914 of revising the weighting factors every ten years as new census information should become available. All computations have been carried back to 1913 in order to insure comparability of the figures and also to provide a prewar standard for measuring wholesale price changes.

The following table gives the revised index numbers for the several commodity groups from January, 1913, to the latest month for which complete information is available. For comparison with the new series, the old general index of all commodities is shown in the last column of the table. Publication of the old series was suspended with the April, 1922, figures.

REVISED INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES AND BY MONTHS, 1913 TO 1922 (1913 EQUALS 100).

	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscellaneous.	All commodities.	
										New index.	Old index.
1913	100	100	100	100	100	100	100	100	100	100	100
January	98	99	99	100	107	101	100	100	106	100	100
April	99	98	100	98	104	103	101	100	100	100	98
July	99	101	100	99	98	99	100	100	100	100	100
October	103	102	101	102	97	98	100	101	98	101	101
1914	103	102	98	93	85	92	101	100	95	98	100
January	103	101	99	99	88	93	98	100	94	98	100
April	102	95	99	98	88	93	97	100	98	98	98
July	103	99	99	91	83	92	95	100	93	97	100
October	101	106	96	88	83	90	108	100	92	97	99
1915	104	105	98	88	99	94	134	100	95	101	101
January	104	106	94	87	82	88	108	99	99	98	99
February	105	108	96	86	86	89	116	99	93	99	101
March	104	106	96	84	88	90	118	99	93	99	99
April	104	105	96	82	90	90	118	99	93	99	100
May	105	105	96	82	96	93	116	100	93	100	101
June	101	102	96	81	102	93	123	100	93	99	99
July	104	104	96	81	106	94	130	100	94	100	101
August	103	102	97	86	103	93	136	100	93	100	100
September	101	99	99	91	104	94	143	100	92	100	99
October	106	102	101	94	105	98	151	100	93	102	101
November	104	106	105	98	110	101	165	100	95	104	103
December	105	108	107	103	122	104	179	101	100	108	106
1916	123	121	127	126	162	120	181	106	121	127	124
January	110	109	110	113	133	110	84	103	110	113	110
February	110	110	114	116	142	113	204	103	105	115	112
March,	111	112	117	119	156	118	206	104	108	119	114
April	113	114	118	120	164	120	200	104	110	121	117
May	115	115	120	120	168	121	193	105	114	122	118
June	114	115	122	122	164	120	191	105	120	123	119
July	117	117	125	121	158	120	175	107	120	123	119
August	125	122	128	116	157	120	157	107	121	126	123
September	131	126	130	120	160	121	158	107	124	130	128
October	136	134	137	128	164	124	164	109	132	136	134
November	147	141	147	155	174	126	167	111	139	146	144
December	146	137	154	163	199	132	172	111	147	149	146
1917	190	167	175	169	231	157	202	125	148	177	176
January	152	140	158	171	198	138	173	118	149	153	151
February	157	146	157	178	204	140	173	119	150	157	156
March	166	148	158	174	218	144	181	120	151	162	161
April	184	164	164	164	230	155	186	121	153	173	172
May	196	175	167	178	240	159	194	121	161	183	182
June	195	171	174	183	267	169	195	123	153	185	185
July	196	169	181	176	292	168	205	129	153	188	186
August	202	175	186	167	282	167	211	129	160	180	185
September	202	176	185	160	260	167	223	130	147	187	183
October	207	180	185	153	207	156	231	130	142	183	181
November	212	181	191	161	183	156	223	131	140	183	183
December	207	181	195	163	183	158	228	133	140	182	182
1918	218	188	228	170	187	172	215	163	156	194	196
January	211	182	201	164	183	161	223	137	145	184	185
February	211	183	205	164	184	161	227	138	145	186	186
March	211	179	211	166	184	164	229	140	147	187	187
April	213	181	220	166	184	169	228	144	152	190	190
May	209	180	226	169	185	170	222	146	156	190	190
June	210	180	233	169	184	172	205	152	160	191	193
July	217	186	238	176	189	177	209	159	169	196	198
Aug.	227	189	239	175	190	179	212	161	160	200	202
September	234	195	245	176	190	179	210	163	161	204	207
October	225	198	245	176	192	177	211	164	163	202	204
November	225	204	241	179	191	177	209	164	164	203	206
December	227	206	233	179	187	177	194	163	163	202	206

	Farm products.	Foods.	Cloths and clothing.	Fuel and lighting.	Metal and metal products.	Building materials.	Chemicals and drugs.	House furnish'g g'ds.	Miscelleaneous.	All commodities. New index.	All commodities. Old index.
1919	231	207	253	181	162	201	169	184	176	206	212
January	224	203	220	178	176	176	181	167	166	199	203
February	216	194	210	178	170	173	169	166	163	193	197
March	224	199	203	178	163	171	162	164	161	196	201
April	230	205	205	177	153	169	160	167	160	199	203
May	234	210	216	178	153	173	161	168	161	202	207
June	226	204	243	180	154	189	162	180	167	203	207
July	241	210	262	181	160	209	167	183	177	212	218
Aug.	242	214	276	184	162	226	170	188	187	216	226
September	225	205	283	188	161	229	170	190	189	210	220
October	227	205	291	189	162	229	173	194	187	211	223
November	237	210	304	188	164	232	176	217	189	217	230
December	242	220	317	189	168	248	182	222	189	223	238
1920	218	220	295	241	192	264	200	254	196	226	243
January	247	231	339	194	175	274	189	239	194	233	248
February	237	222	346	199	190	293	195	242	197	232	249
March	237	220	344	208	197	297	205	242	200	234	253
April	243	238	336	231	203	300	210	242	206	245	265
May	241	248	328	239	202	293	213	247	208	247	272
June	237	243	314	250	200	275	212	248	205	243	269
July	233	238	300	259	202	269	212	275	203	241	262
August	218	221	286	269	202	265	209	274	199	231	250
September	210	215	266	281	200	255	205	273	195	226	242
October	187	201	245	280	191	240	198	271	188	211	226
November	173	190	226	264	176	215	181	260	179	196	207
December	152	170	215	264	160	204	164	242	166	179	189
1921	124	144	180	199	129	165	136	195	128	147	153
January	143	162	196	247	153	192	153	217	154	170	177
February	133	151	188	225	147	180	149	217	147	160	167
March	127	151	183	212	140	173	143	216	139	155	162
April	117	144	176	205	138	167	135	216	130	148	154
May	118	139	173	200	138	165	134	209	126	145	151
June	114	137	172	191	133	163	133	196	125	142	148
July	119	141	172	186	124	160	129	180	123	141	148
August	123	146	171	184	117	156	129	179	119	142	152
September	124	142	178	181	116	156	131	179	118	141	152
October	124	140	180	189	116	159	131	180	118	142	150
November	121	139	180	197	114	163	129	178	119	141	149
December	120	136	180	199	113	158	127	178	121	140	149
1922—											
January	122	131	176	196	112	157	124	178	117	138	148
February	131	136	174	191	110	156	123	177	117	141	151
March	130	137	172	191	109	155	125	175	117	142	152
April	129	137	171	194	113	156	124	176	116	143	152
May	132	138	175	216	119	160	122	176	116	148	...
June	131	140	179	225	120	167	122	176	114	150	...
July	135	142	180	254	121	170	121	173	114	155	...
August	131	138	181	271	126	172	122	173	115	155	...
September	133	138	183	244	134	180	124	173	116	153	...
October	138	140	188	226	135	183	124	176	120	154	...
November	143	143	192	218	133	185	127	179	122	156	...

Capacity of Fabricated Structural Steel Shops of U. S. Totals 250,000 Tons Per Month

According to reports received by the Department of Commerce through the Bureau of the Census, November sales of fabricated structural steel amounted to 46.8 per cent of shop capacity as against 57.3 per cent reported for October.

These percentages are based on a uniform capacity rating recently reported to the Bureau of the Census by almost all the reporting fabricators. Through these new ratings, the total monthly capacity of the 140 identical firms reporting each month from April through November has been reduced from 223,685 tons to 211,510 tons. The following table shows the tonnage booked each month by these firms and the percentage of their revised capacity:

	Tonnage booked.	Per cent of capacity.*
April	193.520	91.5
May	173.588	82.1
June	154.770	73.2
July	143.907	68.0
August	146.621	69.3
September	137.485	65.0
October	121.150	57.3
November	99,040	46.8

On the basis of these revised capacity reports and of known or reliably estimated capacities of other concerns, the Department of Commerce places the present capacity of the fabricated structural steel shops at 250,000 tons per month.

A considerable increase in the capacity of the structural steel fabricating shops of the United States since 1913 is shown in a special survey made by the Department of Commerce. A preliminary report, based on data received from 143 firms with a total revised capacity rating of 208,440 tons per month, shows an increase since 1913 of 45,025 tons in monthly capacity, or about 22 per cent.

The following table shows the total monthly capacity for each year as reported by the above firms, representing about 83 per cent of the present estimated capacity of the United States, and the increase over the preceding year and over 1913:

	Total monthly capacity.	Increase over previous year.	Increase over 1913.
1913	163.415	......	......
1914	164.265	850	850
1915	166.500	2.235	3.085
1916	170.900	4.400	7.485
1917	175,935	6.035	12.520
1918	185.060	9,125	21,645
1919	188.800	3,740	25.385
1920	194.675	5.875	31,260
1921	197.575	2,900	34,160
1922	208.440	16,865	45,025

The increase noted in the year 1922 was largely due to the entrance of ship-building concerns into the fabrication of structural steel. In this connection, the Department of Commerce points out that the capacity of structural steel shops is quite elastic in that, when not busy on structural steel, a shop is often used for tank work, railroad cars, shipbuilding, etc., and, similarly structural work may be turned out in tank shops, shipbuilding plants, etc. The capacity figures given in the report refer to that portion of the fabricating capacity that is usually used for structural work; it is capable of expansion or contraction.

The capacity as reported for this survey was defined as the amount of structural steel work that actually could be turned out running single turn on the character and class of structural work that the plant ordinarily secures. Structual work was considered for this purpose as all work using structural shapes.

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*Increased percentages over previous reports for past months due to revision of capacities.

Commercial Training for Engineering Students

The value of supplementary commercial training for engineering college graduates was the basis of research investigations just completed by Dr. W. F. Rittman and W. F. Reilly of Carnegie Institute of Technology, Pittsburgh. In the Carnegie Technical Journal, a quarterly publication of the alumni and students of Carnegie Tech, Messrs. Rittman and Reilly present some interesting information on their investigations.

With the co-operation of the Alumni Office, a study of the present occupations of Carnegie Tech graduates was made. Of the graduates from 1908 to 1921, the investigations showed that approximately 67 per cent of the total engineering graduates are now engaged in commercial or managerial work. This majority becomes significant in consideration of the fact that "engineering" graduates include a wide range of highly technical fields such as mechanical, electrical, civil, chemical, metallurgical, mining, sanitary and science.

A tabulation in the report shows the following percentages of engineering gradutes in all departments who are now in commercial or managerial capacities: Mechanical engineering, 65 per cent; electrical engineering, 60 per cent; civil engineering, 73 per cent; chemical engineering, 59 per cent; commercial engineering, 91 per cent; metallurgical and mining engineering, 67 per cent; sanitary engineering, 60 per cent; science, 77 per cent.

One of the two most important generalizations cited by the authors in their report is that "the great majority of graduates use their technical education as a means of getting into commercial or managerial work. It is believed that a similar study of the activities of the graduates of other technical institutions corresponding to Carnegie Institute of Technology would show this same order of classification, which seems to be natural and in conformity with the trend of the times."

November Construction 30 Per Cent Ahead of Last Year.—Building contracts awarded during November in the 27 Northeastern States (which include about three-fourths of the total construction in the country) amounted to $248,366,000, according to the F. W. Dodge Co. This total is only 2 per cent under the October figure and is 30 per cent over that for November, 1921. Residential construction started in November amounted to $126,468,000, or 51 per cent of the month's total. This is the largest figure for residential building reported since last June. Other important items in the November record were: $29,938,000, or 12 per cent, for business buildings; $29,242,000, or 12 per cent, for industrial buildings; and $27,516,000, or 11 per cent, for public works and utilities.

Retail Prices of Building Materials

Average prices paid November 1, 1922, by contractors for building materials delivered on the job. These prices are secured through the Bureau of the Census and published monthly by the Division of Building and Housing of the Bureau of Standards, United States Department of Commerce.

The report as published by the Division of Building and Housing gives prices at 48 cities, 29 of which are included in the table herewith. Boston, New York, Philadelphia, Chicago, San Francisco and Los Angeles are among the places not listed in the Bureau's report.

Item No.	Commodity.	Unit.	Haverhill, Mass.	New London, Conn.	Rochester, N. Y.	Poughkeepsie, N. Y.	Newark, N. J.	Baltimore.	Richmond, Va.	Columbia, S. C.	Savannah, Ga.	New Orleans.
1.	Common brick	1,000	$24.00	$30.00	$16.25	$18.00	$21.00	$20.00	$18.00	$12.00	$15.50	$15.75
2.	Portland cement, excl. of containers	Bbl.	3.20	3.68	3.35	3.30	3.10	3.20	3.60	3.85	4.00	3.60
3a.	Yellow pine, No. 1, dimension 2x4—16', S1S1E	M	65.00	50.00	45.00	44.00	48.00	39.00	40.00	.....	29.00	40.00
3b.	Douglas fir, No. 1, dimension 2x4—16', S1S1E	M	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3c.	N. Carolina pine, No. 1, dimension 2x4—16, S1S1E.	M	52.00	.....	.....	44.00	.....	.....	.....	22.50	.....	.....
4.	Common boards, No. 1, 1x6	M	43.00	40.00	40.00	39.00	45.00	.....	34.00	25.00	.....	45.00
5a.	Y. P. flooring edge, grain "C." 1x4—10'—16'	M	110.00	85.00	120.00	.....	90.00	.....	75.00	35.00	.....	.....
5b.	Douglas fir V. G., No 2, 1x4—10'—16'	M	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6a.	Red cedar shingles, extra clear, 16", 5 to 2	100 sq. ft.	6.50	7.00	6.25	.....	7.50	.....	.....	6.75	.....	.....
6b.	Cypress shingles, extra clear, 16", 5 to 2	100 sq. ft.	.....	.....	.....	.....	.....	.....	.....	6.75	.....	.....
6c.	Composition shingles, crushed slate surfaced	100 sq. ft.	7.50	6.50	.....	6.50	.....	.....	6.00	6.25	7.00	.....
7.	Gypsum plaster board, ⅜"	1,000 ft.	.....	35.00	31.00	.....	.....	45.00	40.00	35.00	45.00	45.00
8.	Lime, HYD. com	Ton	19.00	.....	19.00	20.40	.....	15.00	20.00	20.00	23.00	.....
9.	Building sand	Cu. yd.	2.50	1.50	.....	1.80	2.00	2.00	3.04	1.00	2.25	2.00
10.	Crushed stone, ¾"	Ton	2.50	2.80	.....	2.28	2.85	.....	3.40	3.00	5.50	.....
11.	Wire nails	Keg	4.30	4.50	3.85	3.90	3.75	3.40	3.50	4.00	4.50	3.60
12.	Window glass, single A, 10"x12"	50 sq. ft.	.....	.....	4 34	.....	.....	4.20	4.50	.....	.....	.....
13.	Hollow tile, 8"x12"x12"	Each	27	.25	.21	.21	.....	.21	.25	.20	.....	.23
14.	Cast iron soil pipe, 4" E. H., 13 lbs. per ft	Ton	.....	.....	55.00	.....	.....	.....	.....	.....	.....	.....
15.	Steel pipe, 1" galv	100 ft.	11.50	.....	.....	.....	.....	9.00	9.25	10.15	.....	10.37
16.	Reinforcement bars, ¾" square	100 lbs.	4.00	4.25	3.20	4.50	3.29	3.25	3.25	4.00	3.25	4.00
17.	Structural steel, fab. 6" I beams	100 lbs.	4.80	.....	3.75	.....	.....	.....	4.10	4.00	.....	3.65
18.	White lead, dry	100 lbs.	12.75	.....	13.50	.....	11.00	.....	12.50	14.00	13.00	11.75
19.	Zinc oxide, Am. process lead free	100 lbs.	.....	.....	.....	.....	.....	.....	15.50	18.50	.....	.....
20.	Gypsum plaster, neat	Ton	.....	.....	18.00	.....	18.00	22.50	22.00	21.00	21.00	22.00
21.	Linseed oil, raw, in bbls	Gal.	.98	.....	1.23	.....	1.05	.91	.92	1.25	1.20	.98
22.	Roofing slate, No. 1 ribbon	100 sq. ft.	.....	.....	12.00	.....	.....	.....	13.00	.....	.....	.....
23.	Tar paper, roofing, 2-ply, 75 lbs. per roll of	100 sq. ft.	3.00	.....	2.50	.....	2.50	.....	2.00	.....	1.90	2.25
24.	Rosin sized sheathing, 3-ply, 30 lbs. per roll of	500 sq. ft.	1.60	.....	1.05	.....	1.00	1.25	.75	.....	.80	.....

Item No.	Pittsburgh, Pa.	Cleveland, Ohio.	Dayton, Ohio.	Detroit, Mich.	Saginaw, Mich.	Milwaukee, Wis.	Waterloo, Iowa.	Council Bluffs, Iowa.	St. Louis, Mo.	Kansas City, Mo.	Grand Forks, N. D.	Sioux Falls, S. D.	San Antonio, Tex.	Tucson, Ariz.	Sacramento, Calif.	Portland, Ore.	Spokane, Wash.	Seattle, Wash.
1.	$14.25	$16.00	$17.00	$17.00	$17.50	$13.00	$18.90	$10.50	$14.50	$16.00	$13.50	$18.00	$13.00	$12.00	$17.00	$19.00	$.....	$20.00
2.	2.85	3.40	3.52	.....	3.25	2.65	2.80	3.00	2.85	2.80	4.00	2.76	2.70	4.30	3.40	3.40	2.88	3.00
3a.	52.00	57.00	45.00	55.00	50.00	42.00	45.00	48.00	46.00	46.00	.....	.....	50.00	.....	.....	.....	.....	.....
3b.	.....	.....	.....	55.00	.....	.....	45.00	46.00	44.00	46.00	50.00	47.50	.....	60.00	41.50	18.00	28.00	20.00
3c.	.....	.....	45.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.	49.00	50.00	60.00	.....	42.00	37.00	45.00	48.00	49.00	51.00	48.00	44.00	50.00	62.50	43.00	21.00	.....	20.00
6a.	77.00	92.00	90.00	.....	100.00	75.00	80.00	100.00	76.00	72.50	.....	92.00	80.00	.....	.....	.....	.....	.....
5b.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	95.00	80.00	.....	97.50	81.50	56.00	70.00	56.00
6a.	7.50	5.76	.....	8.00	7.00	.....	6.50	7.00	6.54	6.50	7.50	.....	8.00	7.00	.....	5.00	.....	3.65
6b.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6c.	6.25	6.00	6.00	7.50	6.00	7.00	7.50	8.00	6.23	5.80	8.00	7.50	.....	.....	.....	14.00	.....	.....
7.	37.50	46.00	32.50	50.00	40.00	32.00	32.00	.....	41.00	45.00	60.00	36.00	.....	55.00	.....	35.00	55.00	34.00
8.	22.00	16.80	.....	22.00	16.00	.....	25.00	.....	20.00	24.00	.....	22.50	22.50	.....	32.00	26.00	27.25	20.00
9.	2.50	2.50	1.80	2.87	2.50	2.00	1.75	3.50	2.60	2.35	3.00	1.50	1.80	1.15	1.50	1.60	.....	1.75
10.	5.50	3.50	2.50	3.00	3.55	2.10	3 50	5.00	.....	3.00	.....	2.50	2.50	3.00	2.75	2.80	.....	2.00
11.	3.15	3.30	3.90	3.80	3.25	3.25	5.00	5.25	.....	4.50	5.00	.....	4.40	6.00	.....	4.90	.....	4.15
12.	5.58	.....	4.50	4.50	5.20	4.50	.....	.....	4.25	4.50	4.80	6.00	5.40	.....	4.63	5.00	4.80	4.42
13.	.21	.....	.18	.21	.17	.14	.14	.14	.....	.22	.....	.16	.....	.18	.....	.....	.....	.30
14.	30.00	.....	.....	.....	51.00	.....	50.00	.....	.....	.....	.....	.....	78.00	.....	83.16	.....	.....	75.00
15.	9.35	.....	8.57	9.44	9.50	11.50	12.00	.....	.....	.....	12.86	.....	.....	11.95	10.85	12.00	12.38	12.00
16.	3.25	3.00	3.00	.....	3.60	.....	3.35	3.15	.....	2.95	4.85	4.00	.....	4.50	.....	3.85	4.00	3.00
17.	2.80	.....	3.25	4.75	5.00	.....	4.80	.....	4.00	.....	.....	4.25	.....	.....	.....	5.50	.....	5.00
18.	13.25	13.25	15.00	13.25	13.50	12.25	14.00	.....	12.75	12.25	.....	14.00	13.00	14.50	12.50	12.00	12.25	11.75
19.	14.40	.....	12.00	.....	18.00	18.00	17.00	.....	.....	.....	.....	.....	.....	.....	13.00	15.00	13.00	.....
20.	22.00	.....	19.00	17.50	17.00	.....	18.00	18.00	18.50	15.50	.....	17.00	22.50	23.00	.....	24.00	18.00	21.00
21.	.90	1.01	1.20	.98	1.05	1.00	1.12	1.10	1.02	.90	.....	1.00	.97	1.18	1.07	1 05	1.05	1.05
22.	13.50	.....	.....	.....	16 00	.....	16.00	.....	.....	.....	.....	.....	.....	.....	.....	22.00	.....	.....
23.	1.95	2.50	2.25	.....	3.25	.....	.....	.....	.....	.....	2.85	2.70	2.40	3.50	.....	.....	2.05	2.60
24.	1.20	.90	1.15	.....	.....	1.00	1.50	1.50	.....	1.20	1.50	1.30	.....	1.60	.....	1.60	.....	1.20

Pittsburgh Steel and Iron Prices.

The following data on prices and freight rates are taken from The Iron Age of December 21:

Plates, sheared, tank quality, base, per lb	1.95c to 2c
Beams, channels, etc.	2.00c
Soft steel bars, base, per lb	2.00c
Track spikes, 9/16 in. and larger, base, per 100 lb	$2.75
Track spikes, ½ in. and smaller, base, per 100 lb	3.50
Spikes, boat and barge, base, per 100 lb	3.50
Track bolts, base, per 100 lb	3.75 to 4.50
Tie plates per 100 lb	2.35
Angle bars, base, per 100 lb	2.75
Butt welded steel pipe, ¾ in.—Black 64; galv	.52¼
Butt welded steel pipe, 1 to 3 in.—Black 66; galv	.54½
Lap welded steel pipe, 2½ to 6 in —Black 63; galv	.51½
Pig iron, No. 2X, Philadelphia, per gross ton	$28 76
O.-h. rails, heavy, at mill, per gross ton	43.00
Light rails (25 to 45-lb. sections), at mill, per lb	2.10c

Freight Rates.

All rail freight rates from Pittsburgh on domestic shipments of finished iron and steel products, in carload lots, to points named, per 100 lb. are as follows:

Philadelphia	$0.325	Kansas City (pipe)	0.705
Baltimore	0.315	St. Paul	0.60
New York	0.34	Omaha	0.735
Boston	0.365	Omaha (pipe)	0.705
Buffalo	0.265	Denver	1.27
Cleveland	0.215	Denver (pipe)	1.215
Cleveland, Youngstown, comb.	0.19	Pacific Coast	1.50
Detroit	0.29	Pac Coast, ship plates	1 20
Cincinnati	0.29	Birmingham	0.69
Indianapolis	0.31	Memphis	0.385
Chicago	0.34	Jacksonville, all rail	0.50
St Louis	0.43	Jacksonville, rail and water	0.415
Kansas City	0.735	New Orleans	0.515

Hollow Tile Investigation of U. S. Bureau of Standards.

An investigation of the fire-resistance and related physical properties of hollow building tile has been conducted by the U. S. Bureau of Standards during the past two years in co-operation with the Hollow Building Tile Association. A furnace, suitable for making fire tests of small panels up to 4 ft. square, was built and tests of unprotected panels built from tile of representative clays have been made in order to establish characteristic behavior under fire. A wide range in fire resistance was found, depending mainly on the mineral composition of the clays employed. As a possible means of increasing fire resisting properties, grog additions up to 10 per cent were tried, but it was found that the small addition which can be conveniently made in manufacturing practice had no effect, and that additions of 5 per cent or more decreased the fire resistance. The protection afforded by typical plasters has been determined, obtaining, generally, excellent results. The effect of the addition of combustible filler to the raw material, of the fineness of grinding of the raw material, of the size of the unit and of changes in design of the tile, will be ascertained.

In conjunction with the fire tests, determinations of the absorption, compressive strength, expansion, mineralogical composition, and ability to withstand freezing are being made. Several different methods for determining the absorption were tried, and as a result saturation of the specimens by boiling 5 hours and allowing to soak in water at room temperature for at least 1 hour before taking the saturated weight, was adopted as giving the most practical and consistent results for inspection work. This part of the investigation has been reported in a paper on "Effectiveness of Different Methods of Making Absorption Determinations" in Vol. 5, No. 11, of the Journal of the American Ceramic Society. The method of preparing tile for compressive strength tests was studied in a series of tests in which tiles with various caps at ages from 1 hour to 7 days, were used. The results, according to a Technical News Bulletin of the Bureau, indicated that a cap of 3 parts of portland cement to 1 part of unretarded gypsum (plaster of Paris) at the age of 7 days gives the highest and most consistent strengths.

Steam Heating Main Capacity and Critical Velocity of Steam

A study of the laws governing the size of steam pipes carrying steam at low pressure was the basis of research work conducted during the summer at Carnegie Institute of Technology, Pittsburgh, according to an announcement from the institution. The research study, which will be continued next summer, was carried on in the Heating and Ventilation Department of Carnegie Tech by Professor L. S. O'Bannon, of the University of Kentucky. The work was financed by Carnegie Tech, on its own initiative, as a further step in its plan to tie up its educational facilities with outside industry.

The technical title of Professor O'Bannon's problem was: Capacities of Steam Heating Mains as Affected by Critical Velocities of Steam and Condensate Mixtures. His particular work during the past summer was a study of the effect of the shape of pipe entrance on critical velocity. He also attempted, in an experimental way, to go deeper into the theory of flow of steam in one-pipe system heating mains in order to find an empirical law which may be used for purposes of general design.

From this point of view he has shown tentatively, but not conclusively, that the maximum velocity in vertical pipes is equal to the acceleration due to gravity modified more or less, depending upon the size of the pipe and the nature of the internal surfaces.

In the experiments to determine the effect of variously shaped entrances, such as squared, rounded, reamed, and contracted entrances due to the use of cutters without reaming, the results seem to lead to the conclusion that the capacity of a pipe with a restricted entrance is no more than, and very nearly equal to the capacity of a pipe of uniform cross section throughout its length with an area equal to the area of the constriction in the larger pipe. There is only slight advantage in rounding or reaming a pipe further than removing sufficient metal to leave the entrance of the pipe free from any constriction.

Cost of Public School Buildings

The following table reprinted from the Improvement Bulletin shows the cost of several schools erected in different parts of the country:

	Year built.	Total cost.	Cost per cu. ft. Ct.	Cost per pupil.
Erie, Pa., High School	1919	$924.337	30.16	$424.98
Savannah, Ga., Junior High School	1920	401.257	38.11	393.38
Waltham, Mass., Junior High School	1922	256,000	32	400.00
Denver, Colo., Junior High School	1921	540,000	37	470.00
Cleveland, O., Elementary School, including equipment	1920	494,000	49.4	785.00
Richmond, Ind., Junior High School, including equipment	1922	398,000	39.5	797.00
Framingham, Mass., Elementary School	1920	202,000	32	345.00
Great Neck, N. Y., Elementary School	1921	....	42	......
Hempstead, N. Y., High School	1921	654.000	37.4	445.00
Berkeley, Cal., High School	1920	361,623	34.6	......
Berkeley, Cal., Elementary School	1919	102,264	18.7	......
Akron, O., High School	1917	384,111	24.67	231.29
Birmingham, Mich., High School	1917	....	24	417.00
Glassboro, N. J., Normal School	1922	476.703	37.2	......
Walpole, Mass., Elementary and Junior High	1921	145,000	28	233.00
North Woburn, Mass., Elementary School	1922	....	32	361.00
Rockville Center, N. Y., Elementary School	1921	100,000	45	......

Elevators Not So New

In the November issue of the Journal of American Institute Architects, in an article entitled "The Passing of the Skyscraper," Mr. George C. Nimmons refers to the fact that the elevator in buildings is by no means exclusively a modern institution, and offers the following in evidence thereof:

We didn't invent the elevator but only applied mechanical power to operate it. Archimedes had a freight elevator in 236 B.C. operated by perfectly good hand power, according to Vitruvius who recorded a description of it in 46 B.C., when he was working for Julius Caesar as a military engineer. This must have led to the invention of the animal elevator which was installed at the Roman Coliseum for raising the wild animals up to the level of the arena floor.

The passenger elevator would probably be traced 'way back to the sixth century at the Convent of St. Catherine on Mt. Sinai, and then at the Monastery of St. Barlaam in Greece, where one had a travel of two hundred feet. Queen Anne had a passenger elevator at Windsor Castle, and the Empress of Austria, Maria Theresa, in 1780, at the Capuchin Church in Vienna, had one which she used for descending to the family tomb in the crypt. It is reported that this was of the plunger type. At any rate, it stuck in the hatchway, one day,—a not uncommon occurence even now,—but the Empress, who was very strong for omens, took this as a bad one and assumed it to be the forerunner of her death, which really did occur a short time afterwards.

Novel Construction Features in Erection of Reenforced Concrete Arch

Somewhat unusual construction methods were adopted in an erection of the new high level reinforced concrete arch bridge complete last autumn over the Irvine river near Elora, Ont. An interesting description of this work was given by Mr. A. W. Connor, consulting engineer, Tronto, Ont., in a recent issue of The Canadian Engineer, from which the matter following is taken.

The first bridge was built about 1853. Long timbers were run out from either side and lashed together by two sailors brought up from the Atlantic coast. These were then trussed up and the wooden bridge completed. In 1887 a masonry pier was built in the gorge and the old bridge was replaced by a steel deck bridge of two 60-ft. spans. This bridge has been in service ever since and was used to advantage in the erecting of the new concrete arch bridge.

The old pier was in excellent condition, having been constructed by English masons and the stones bonded together with iron anchors. It was 10 by 24 ft. at the base, tapering to 4 ft. 3 in. by 18 ft. at about the spring of the new arch. At this elevation there was a 6-in. offset and the upper part was carried up plumb. The pier was used without alteration below this bridge. Above this ledge, recesses were cut on the sides to receive the new arch ribs. After the ribs had set and some weight could be taken off the shores of the bridge, the pier was cut down to make room for the concrete columns and above the extrados narrowed, for appearance to the width of the columns.

New Superstructure.—The new bridge consists of two open-spandrel arch spans of 61 ft. with a 19-ft. roadway and a 5-ft. sidewalk on one side. The clear distance face to face of abutments is 123 ft. and the height of the floor above the water is 85 ft. The bridge is designed for a uniformly distributed live load of 135 lb. per square foot or for a concentrated load of 20 tons, being class "C" loading of the specifications of the Ontario Department of Highways.

There are two parabolic arch ribs with a rise of 12.2 ft. 24 in. thick and 30 in. deep at the crown. The ribs are 12 ft. 4 in. apart in the clear, being just wide enough to permit the forms to clear the old steel trusses. The overhang of the brackets is 5 ft. 10 in. on the sidewalk side and 3 ft. 10 in. on the other. The arches contain 7 panels of 8 ft. 10 in. with semicircular spandrel sub arches. The deck consists of a 10½-in. concrete slab on the roadway and a 4-in. slab for the sidewalk, carried by floor beams at the panel points. The railing is 4 ft. high on the sidewalk side and 4 ft. 6 in. on the roadway side, the sidewalk being 6 in. higher than the road. The open panels and top rail of the balustrade were precast, the former in two sections.

Erection Without Falsework.—On account of the height of the structure, it was designed for erection without falsework, using the old steel trusses to support the new arch ribs. It was found that the old bridge was just strong enough to carry the ribs without the deck. To provide extra security, the forms for the ribs were built to act as an arch, with a horizontal tie consisting of old lateral rods used when the rib was being poured. The old bridge was a 5-panel, pin-connected deck, 60-ft. span with 12-in. I's 16 ft. long over the trusses which were 11 ft. centre to centre. It was arranged to allow the two centre I-beams to pass under the arch ribs. By putting 2-in. fillers under the other beams, they just passed over the ribs. The weight was carried to them by heavy iron stirrups. Each rib was poured uniformly from each end and a key section poured the following day. As the load on the truss was eccentric, the platform over the unloaded truss was counter weighted with stone. As each rib was being poured, a point on the formwork was sighted from a transit and constantly watched against tipping or undue settlement. The latter was about as expected, namely ⅝ in.

By the time the formwork for the deck was completed, the ribs had set sufficiently to carry the weight of the deck. This weight was distributed between the old trusses and the arch ribs. To secure equal settlement, the two systems were tied together.

The two central floor beams pass through the ribs. The steel was inserted and recesses 3 in. deep were left for the bearing of the beams. Expansion is provided in the deck at the ends and over the centre pier, the floor beam at this point being deeper and wider than the others.

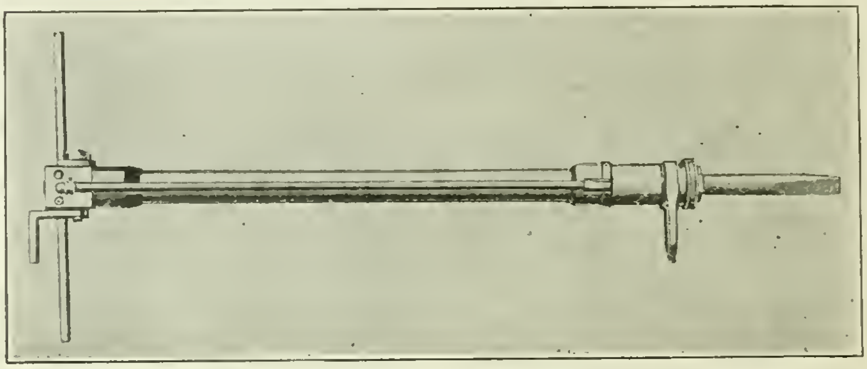
The sidewalk slab was cast after the roadway and sidewalk brackets were completed. Curbs were cast with a slot for the precast panels, the rods for the posts being left projecting. The upper precast rail was cast with a groove to fit over the panel. Post forms were clamped around the panels and rails and poured to bind all together.

Conduits for electric wiring were cast into the curbs. The standards for the lights are also of precast concrete.

The total length of the structure with wing walls is 181 ft. 9 in. There are 311 cu. yd. of concrete and 15 tons of steel in the work. The cost of the bridge was $15,200. The contractors for the work were Reid & Somers, Ltd., of Toronto. The bridge was built by the County of Wellington, Mr. Connor acting as the engineer.

New Rivet Cutter

The Chicago Pneumatic Tool Co., New York, has designed and manufactured a new rivet cutter known as the "Boyer Superior." Its construction consists of a dead handle, a throttle handle of the crank design, a throttle valve of the taper type, a back head screwed onto the cylinder and secured by a locking device, a cushion chamber in the rear end of the cylinder, a cylinder of seamless steel tubing, a bypass from back to front head, a non-removable electrically welded front head, square coiled spring buffer, adjustable chisel lock, hand hold of the spade handle type, and chisel. To operate, the throttle handle is moved in a line parallel with the cylinder. Each forward and return stroke of the piston is hand-controlled. About four blows, requiring approximately 10 to 15 seconds, are said to be required to cut off the head of a ¾-in. rivet. Two men are required to operate the machine.



Boyer Superior Rivet Cutter.

Industrial Notes.

Harry S. Whitehair has been appointed to the National Sales Division of the General Motors Truck Co. of Pontiac, Mich. Mr. Whitehair will devote his time to sales to national organizations which use large fleets of trucks in all sections of the country, paying special attention to the companies which have headquarters outside of New York and Chicago, where other national sales division representatives are stationed.

The Northwest Engineering Co. announces that H. A. Hutchins, well known in his former connection with the Thew Shovel Co., has become associated with the main office of the Northwest Engineering Co., located at 1220 Steger Bldg., Chicago.

Worthington Pump & Machinery Corporation announces the following change in its organization: E. T. Fishwick, formerly sales manager, made vice-president in charge of sales, to succeed F. H. Jones, vice-president, resigned. J. E. Sague, vice-president, resigned, succeeded by William Goodman, formerly assistant to the vice-president. James C. Barnaby, formerly plant engineer of Staten Island Shipbuilding Co now in charge of certain engineering work in Diesel oil engine division of Worthington Pump & Machinery Corporation.

A. R. Ulbrich, formerly sales manager of the Terry Mfg. Co., Inc., has been appointed sales manager of the National Hoisting Engine Co. of Harrison, N. J. He will assume his new duties Jan. 1, 1923.

E. C. Brandt, works manager of the Westinghouse-Krantz Works, has been appointed works manager of the new plant now being erected by the Westinghouse Electric & Manufacturing Company in Homewood, Pittsburgh.

The Bucyrus Co., South Milwaukee, Wis., announces the addition to their sales force of Mr. John J. Gault. Mr. Gault has had many years of experience as construction and locating engineer, having been assistant engineer on the Chicago & Northwestern, engineer maintenance of way on the Chicago & Alton, construction engineer for the United Fruit Co., and assistant engineer on the Chicago, Milwaukee & St. Paul. His last connection was with the International Harvester Co. as locating engineer on a railroad project. He will be attached to the Chicago office of the Bucyrus Co. at 622 McCormick Bldg., Chicago, Ill.

L. R. Phillips has been appointed district sales manager of the Detroit Seamless Steel Tubes Co., and will establish an office in Chicago on January 1st. For the past 20 years Mr. Phillips has been associated with the National Tube Company, seventeen of which were with the Chicago office, and the latter three with their St. Louis office.

S. W. Lendheimer, dealer in rail and track accessories, 1st National Bank Bldg., Chicago, is leaving for Europe on Jan. 26, on the steamer Majestic, to negotiate on large steel contracts which have been pending for some time.

Personals.

George M. Shepard was recently appointed chief engineer, Department of Public Works, of the city of St. Paul, Minn. Mr. Shepard has been associated with Mr. L. P. Wolff of St. Paul during the past several years in general consulting practice of municipal and hydraulic engineering.

Walter G. Caldwell has resigned as county highway engineer of Waukesha County, Wisconsin, and has opened an office at Waukesha, Wis., where he will engage in a civil engineering and surveying practice.

C. H. Eiffert has been appointed maintenance engineer for the Miami Conservancy District, Dayton, O. He has been division engineer in charge of the river improvement work at Hamilton since the beginning of construction about five years ago. Before that he was engaged on the preparation of plans and specifications for various features of the project.

J. R. Vernon has resigned as assistant division engineer for the Wisconsin Highway Commission at Lancaster, Wis. He has accepted a position with the Johnson Service Company, manufacturers, engineers and contractors of temperature regulations and humidity control systems, and will be at the Chicago office of the company, 177 North Dearborn St.

Milton B. Medary, Jr., 47th street and City Line, Overbrook, Philadelphia, has been appointed by President Harding to membership on the Federal Commission on Fine Arts. He succeeds John Russell Pope, of New York, whose term has expired.

Mr. Medary is one of the architects on the Zoning Commission appointed by Mayor Moore, Philadelphia, and is considered widely as an authority on city planning. The Fine Arts Commission was created during the term of Theodore Roosevelt to govern the physical development of the Nation and to regulate the expenditures on all public improvements authorized by the Federal Government.

Obituary.

Michael Byrnes, 72 years old, president of the M. Byrnes Building Company, and the Elizabeth Coal Company, with offices at 4[illegible] Westfield Avenue, Elizabeth, N. J., died of heart disease Dec. 14. Mr. Byrnes was one of Elizabeth's pioneer builders. For half a century he had been identified with the business development of the city. Born in Ireland on May 6, 1850, Mr. Byrnes came to this country at the age of 10 with his parents, the late Timothy and Elizabeth Byrnes. He served an apprenticeship with the carpenter firm of Meeker & Hedden, of Newark, and upon reaching his majority established himself in business for himself. Since then he has erected many of the city's public schools, and many other large structures.